Utilisation du guide WG22 (bon marché) à la place du WG20 en 24Ghz et du WG23 en 47Ghz , réservé aux courtes connections à cause des pertes.

Waveguide WG22 for 24GHz and 47GHz?

Some of you may have seen WG22 around at round tables, rallies, etc, and wondered if it might be of any use. Well the answer is yes!

24GHz

On 24GHz, WG20 is commonly used. It is available new at moderate but not outrageous cost – eg about £5 a foot and £9 a flange from Mainline.

WG22 has a recommended frequency range of 26.5 to 40.0 GHz, with internal dimensions of 7.112 x 3.556 mm. Cutoff is calculated as 21.08 GHz – when the broad dimension equals half a wavelength. So 24GHz will propogate OK, except that the waveguide wavelength gets a bit long: at 24.192, λg works out at 25.2 mm (compared to about 15mm in WG20).

Closer to cutoff, the loss goes up, so that at cutoff, it is theoretically infinity. In WG20, minimum theoretical loss is about 16dB/100ft at 24GHz. In WG22, being closer to cutoff, the loss is somewhat more – about 26dB/100ft minimum. But provided you are only using short lengths, this is not a problem.

There are lots of components around in WG22, some of which work well at 24GHz – eg nice calibrated attenuators, as well as the usual bends, twists and flexiguide. Some things which are less likely to work are couplers and isolators, which will have been designed for frequencies well away from 24GHz.

G4KNZ has successfully built a DB6NT LNA amplifier on WG22 instead of WG20 (the probes into the guide need to be changed in position and length).

One problem found was trying to design a filter using cavities defined by iris plates with round holes. To make a filter with a bandwidth of 100MHz or so, the iris hole sizes have to be bigger than the height of the guide. In WG20, they are well under the guide height. So use rectangular holes or a post type filter instead.

A transition to WG20 can be made from a piece of WG20 with a flange on one end, cut, tapered and filed down to fit into a WG22 flange at the other end. Make the taper reasonably long enough – eg a few wavelengths.

Given that WG22 bits have been bought as cheap as 10 pence an item, this could be a cheaper way of getting going on 24GHz.

47GHz

Normally, WG23 or WG24 would be used. But, for example, from Mainline, WG23 costs over £30 a foot – the smaller guides and flanges are a lot more expensive because it is hard to make them with the accurate tolerances specified. Flanges are dear too – about £13 each for WG23! WG23 has internal dimensions of 5.69 x 2.845 mm.

So what about WG22?

The upper recommended limit of WG22 is 40GHz. Above 42GHz, overmoding can occur, and by 47.1GHz, several modes are possible. In practice, G4KNZ has found short lengths working well at 47 to 48GHz, with no noticeable loss due to overmoding. Bends seem fine too.

Components such as attenuators, though, do not now seem to work so well, whereas they did on 24GHz. Perhaps the energy sneaks past in a different mode. Again, things like couplers and isolators are not likely to work, having been designed for much lower frequencies than 47GHz.

One nice feature is that the WG22 square flange mates with a WG23 flange, with the same fixing hole positions. And the step between the two guides does not seem to give excessive loss, though it would be easy to make a taper. With a calibrated attenuator, a source and detector, all in WG23, G4KNZ found it was not possible to measure the loss of a few inches of WG22 placed in the WG23 system (at 48GHz).

From K&S, come lots of model making brass sections, rods, etc. Included are various sizes which can be used as waveguide. For example, K&S size 264 has internal dimensions 5.55 x 2.38 mm, and external dimensions of 6.35 x 3.18 mm. What's more, it only costs about £2 a foot.

The internal size is fairly close to WG23, and would be a good choice for the 47GHz band.

One idea tried by G8KMH, is to fit this inside WG22. It is a loose fit (WG22 internal is 7.112 x 3.556 mm), but it can be centred with packing, eg a bit of copper foil wrapped round each end. Then it can be soldered in place. The K&S section has thin walls and easily collapses - so be careful not to force it in the WG22. If the piece of WG22 already has flanges, then you end up with a very strong assembly with flanges what will mate with WG23 with now much less of a step (than to WG22), and a guide which will not overmode.

Again, with WG22 bits seen as low as 10 pence a piece (with flanges), it has to be worth considering!

73 de Steve, G4KNZ.

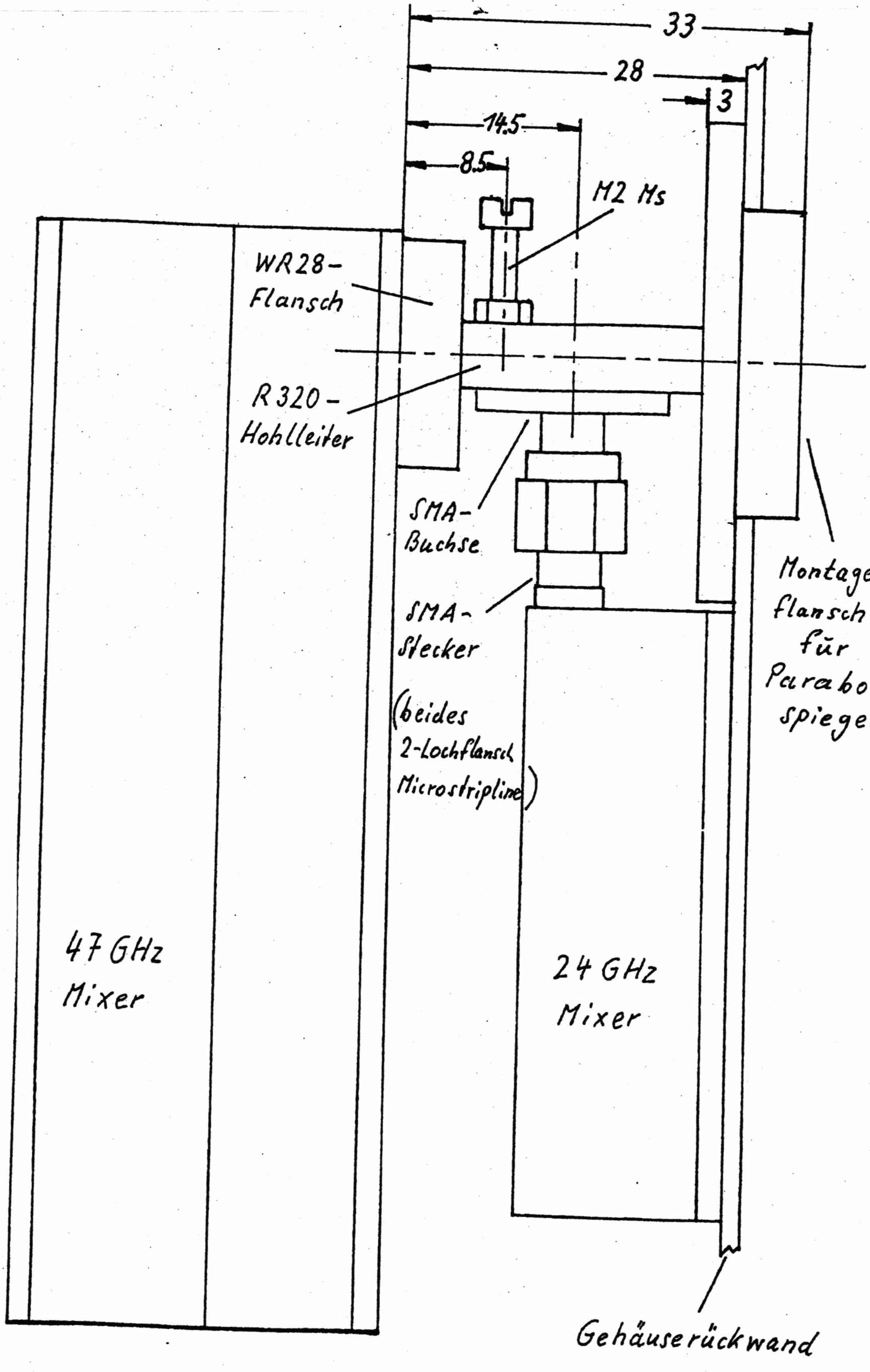
Duoband-Transverterkonzept für 24 und 47 GHz
- Eine einfache aber geniale Lösung für den Portabeleinsatz -

Jürgen Dahms, DCϕDA, Brandbruchstraße 17, 44265 Dortmund

Einleitung

Neben dem 10 GHz Amateurfunkband gewinnen die beiden Bänder 24 und 47 GHz immer mehr an Bedeutung. Speziell im Raum Nordrhein-Westfalen ist hier bei Kontesten eine steigende Aktivität zu verzeichnen, wobei gerade das 47 GHz-Band seine besonderen Reize hat (es klappt eben nicht immer sofort und auch nur bei bestimmten Witterungsverhältnissen). Wer einmal versucht hat, über eine größere unbekannte Strecke sofort auf 47 GHz in Kontakt zu kommen, weiß um die Schwierigkeiten einer solchen Verbindung! Es ist daher fast zwingend notwendig, erst einmal die Distanz auf dem 24 GHz-Band zu überbrücken, die Parabolspiegel exakt auszurichten und an Hand der Feldstärken eine Beurteilung der Situation vorzunehmen. Selbst bei relativ hohen Feldstärken liegen dennoch „Welten" zwischen 24 und 47 GHz, manch eine Verbindung scheitert dann letzendlich doch auf 47 GHz.

Demnach sind für die 24 GHz-Verbindung Eingangsempfindlichkeiten und Ausgangsleistungen von subharmonischen Mischern vollkommen ausreichend. Auch die Spiegelgröße darf im unteren Limit liegen (z. B. 25 cm ∅). Werden hiermit beachtliche Feldstärken erzielt, ist ein Zustandekommen der 47 GHz-Verbindung quasi vorprogrammiert.



Skizze der HL-Einkopplung 47 u. 24 GHz
für Duoband-Transverter
(in der Draufsicht M ~ 2:1)

06/98 dc∅da

47 GHz Verstärkertechnik

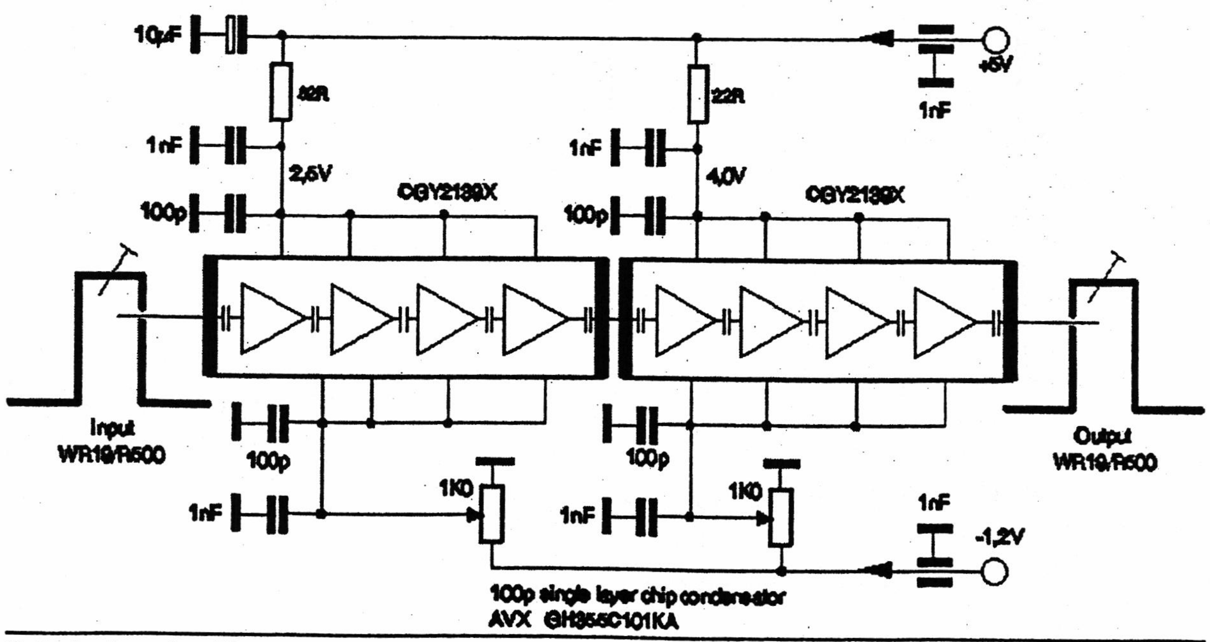
DB 6 NT Michael Kuhne 7.2002

Die Realisierung eines rauscharmen Vorverstärkers mit brauchbaren technischen Daten für das 47 GHz Amateurband war bisher nicht möglich. Lediglich wurden hochkommerzielle Verstärker für die Militärtechnik oder Radioastronomie zu entsprechenden Preisen angeboten. Seit einiger Zeit sind jedoch Verstärkerchips von verschiedenen Halbleiterherstellern erhältlich, die gute Verstärkerdaten liefern.
Leider sind dies reine Halbleiterchips, die zur Kontaktierung der Anschlüsse gebondet werden müssen. Dies setzt den Zugriff auf eine entsprechende Bondanlage voraus. Versuche mit gehäusten GaAs FET's wurden schon in den Neunziger Jahren unternommen, die jedoch keinerlei Verstärkung aufwiesen. Dies ist hauptsächlich auf die Gehäuse und deren parasitären Eigenschaften (Induktivitäten) zurückzuführen. Selbst CFY77 mit abgefeilten Gehäuseboden und direkter Montage auf der Leiterplatte blieben ohne jeglichen Erfolg. Alle Anstrengungen, die Bondtechnologie zu umgehen, scheiterten.

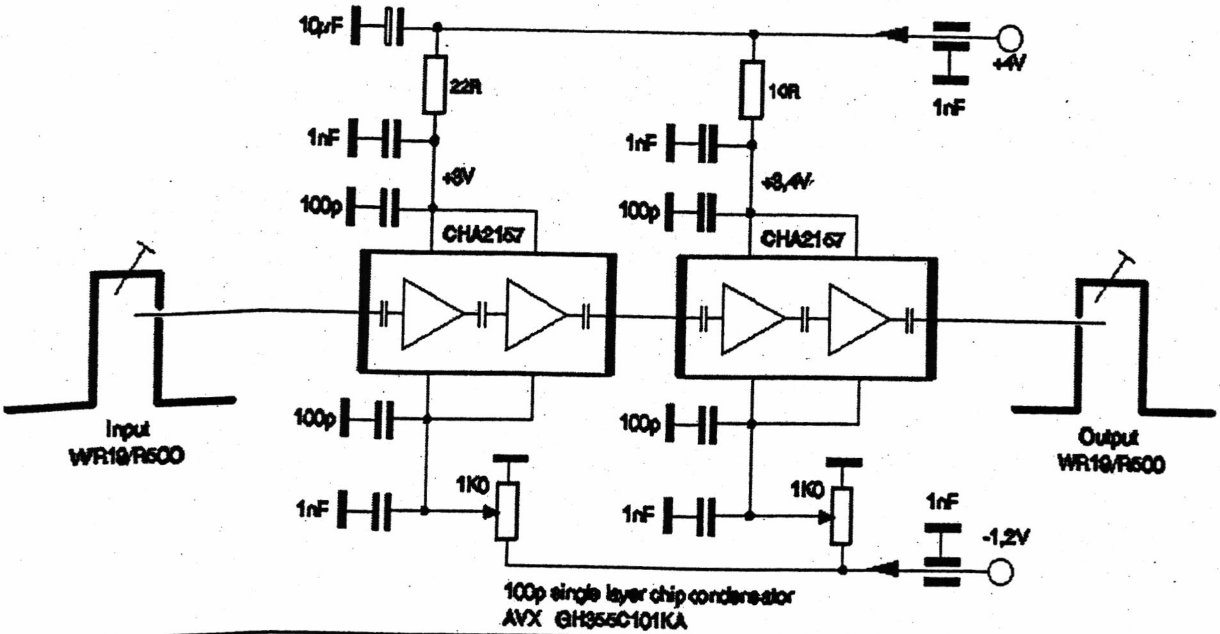
Hersteller

Chips werden von Firmen wie z.B. UMS, TRW, Philips, HP, ALPHA, SIEMENS, NEC, FUJITSU, MITSUBISHI oder anderen hergestellt. Die meisten Halbleiter werden jedoch für kommerzielle Frequenzbereiche gefertigt. Das ist z.B. der Bereich von 38...44 GHz oder 55...60 GHz. Für das Amateurband um 47,088 GHz wird leider kein Chip produziert, so dass Standardhalbleiter verwendet werden müssen, die außerhalb ihres normalen Frequenzbereiches betrieben werden und somit nur eingeschränkt die technischen Daten der Hersteller erreichen.

Verwendet wurden zum einen der von PHILIPS hergestellte Chip CGY2139X (30...44 GHz) mit dem zwei Verstärker aufgebaut wurden. Zum anderen wurden weitere Verstärker mit UMS Chips vom Typ. CHA2157 (55-60 GHz), CHA2194 (36-44 GHz) und APH403 (37-45GHz) aufgebaut. Zur Anwendung kamen jeweils zwei Verstärker Chips in Serienschaltung, um eine hohe Durchgangsverstärkung zu erzielen. Dies ist nötig um die relativ schlechte Eingangsrauschzahl des nachgestalteten Subharmonikmischers mit Spiegelfrequenzfilter zu verbessern.



Schaltplan des Verstärkers mit 2x CGY2139X



Schaltplan Verstärkers mit 2x CHA2157

Aufbau

Der Aufbau erfolgt auf einer 5 mm starken und 30 x 50 mm großen Messingplatte mit entsprechenden Ausfräsungen für Hohlleiter und Bohrungen für die verstellbaren Abstimmschieber. Die Montage der 0,12mm starken RT/duroid 5880 ROGERS Leiterplatte erfolgt durch Auflöten. Hierzu ist die Messingplatte vorher zu verzinnen. Durch diese Anordnung ergibt sich eine direkte Einkopplung von der Leiterplatte in den Hohlleiter. Ferner lässt sich der Verstärker axial drehen und somit als „Wendeverstärker" für Senden und Empfang nutzen.

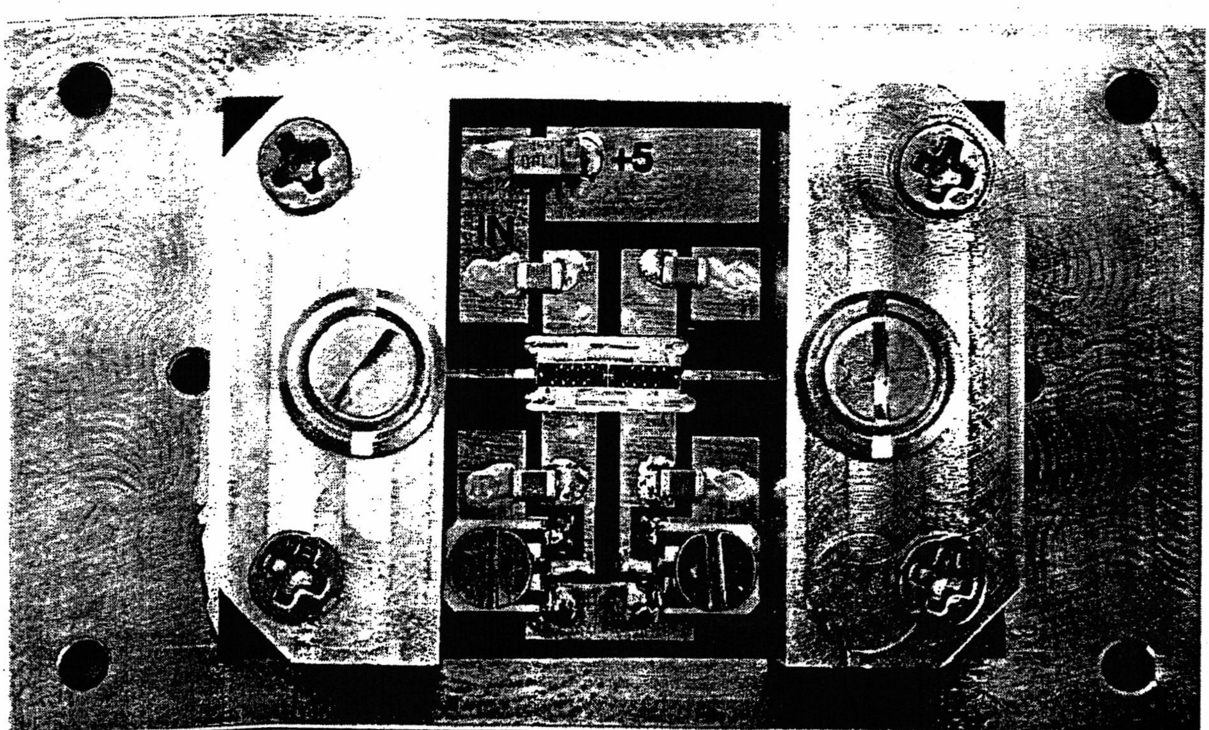


Foto des Verstärkers mit 2x CGY2139X

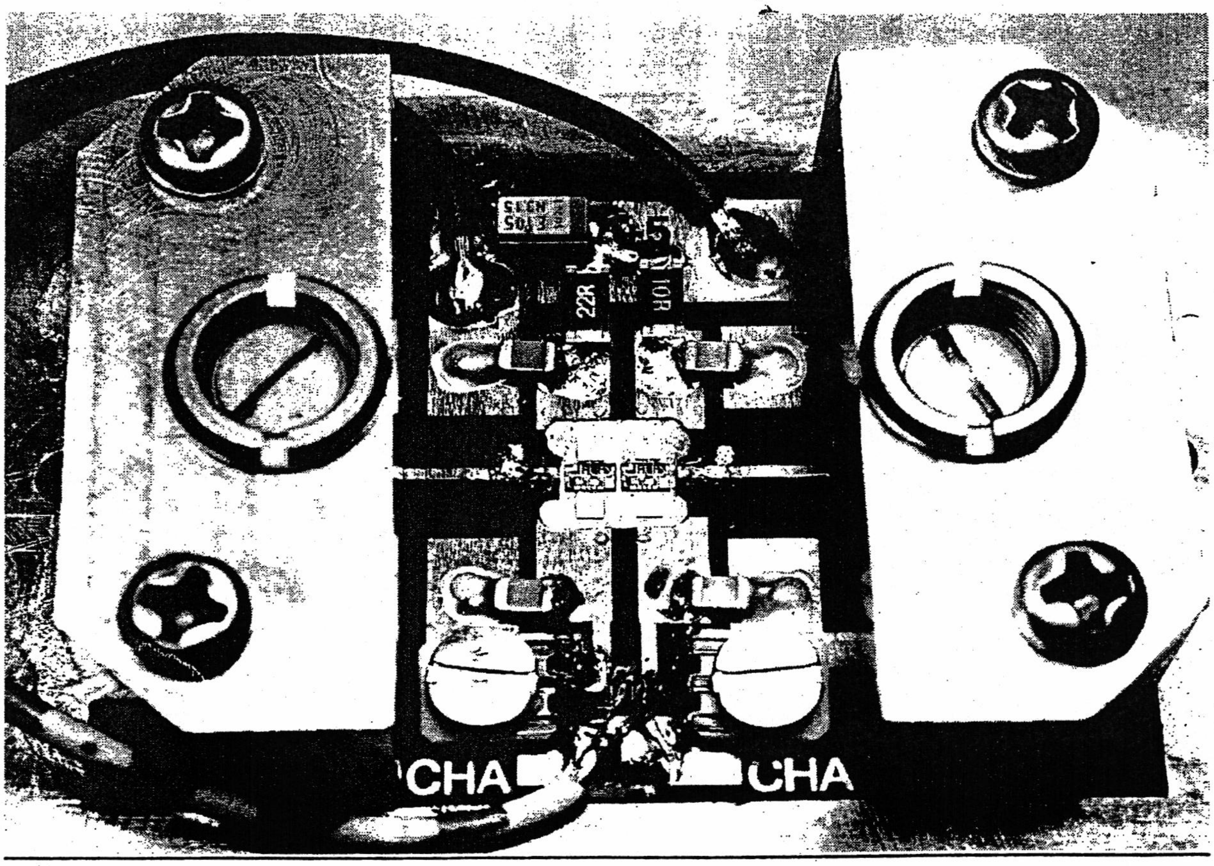
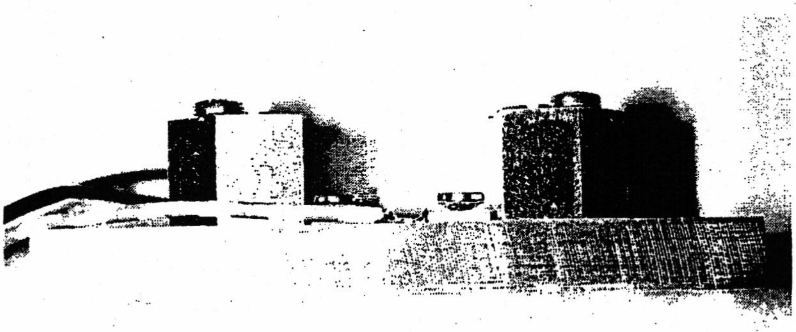
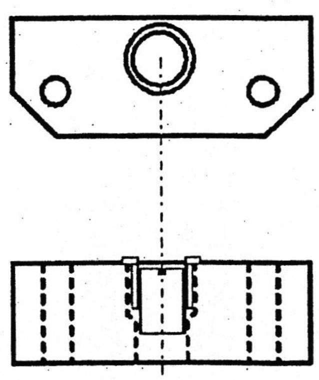


Foto: Verstärker mit 2x CHA2157 nach dem Abgleich

Bonden

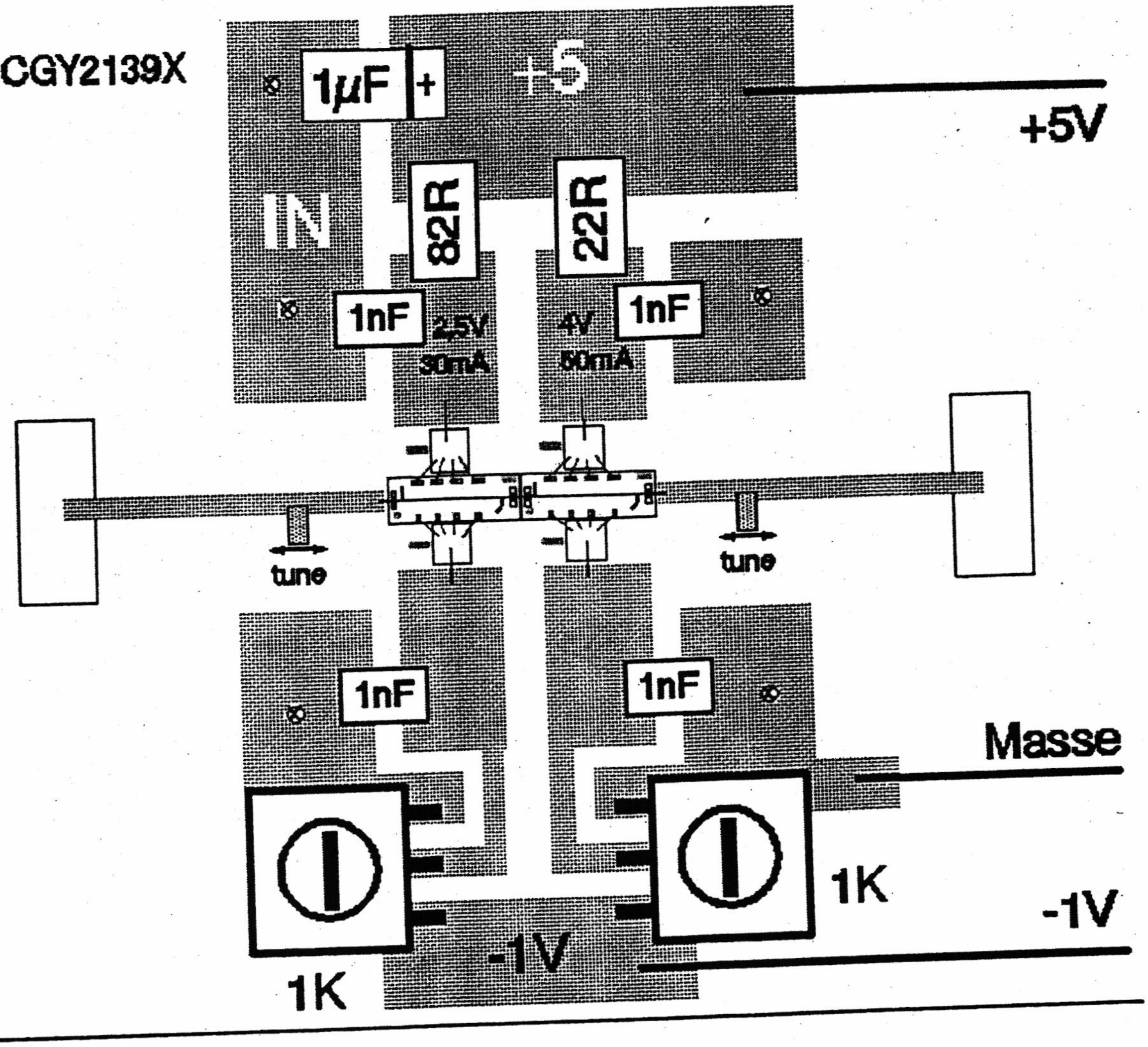
Die Verstärkerchips werden in eine Ausfräsung der Leiterplatte eingeklebt (die-bonding) und im „wedge-wedge“ Bondverfahren mit 25µ Golddraht ohne Bondloop mit der Leiterplatte verbunden. Der Spalt zwischen Leiterplatte und IC sollte dabei so gering wie möglich sein, um kurze Bonddrahtlängen und somit gute HF-Eigenschaften zu erreichen (Bonddraht = Induktivität = Tiefpass!). Die Versorgung der Halbleiter mit Betriebsspannung für Gate und Drain erfolgt über Bondverbindungen mit normaler „loop“ auf „singellayer Chipkondensatoren“ die unmittelbar neben den Verstärkern eingeklebt sind und dann weiter auf die Leiterplatte. Die Chipkondensatoren sind notwendig, um Schwingneigungen durch zu lange Bonddräte zu minimieren und somit eine gute HF Abblockung zu erreichen. Das Bonden auf weichen Substraten (6) wie TEFLON erfordert höhere Ultraschall -Leistung als auf den Halbleiter. Um eine optimale Haftung der Drähte auf der Kupferleiterbahn zu erreichen wurde zusätzlich etwas Leitkleber aufgetragen.



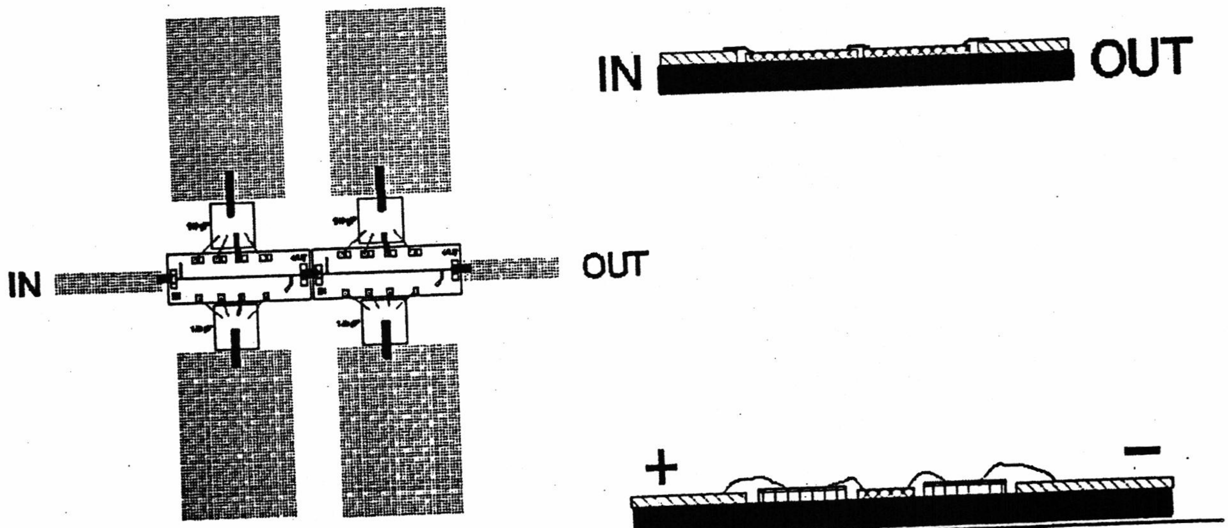


Seitenansicht **Skizze**

2 x CGY2139X

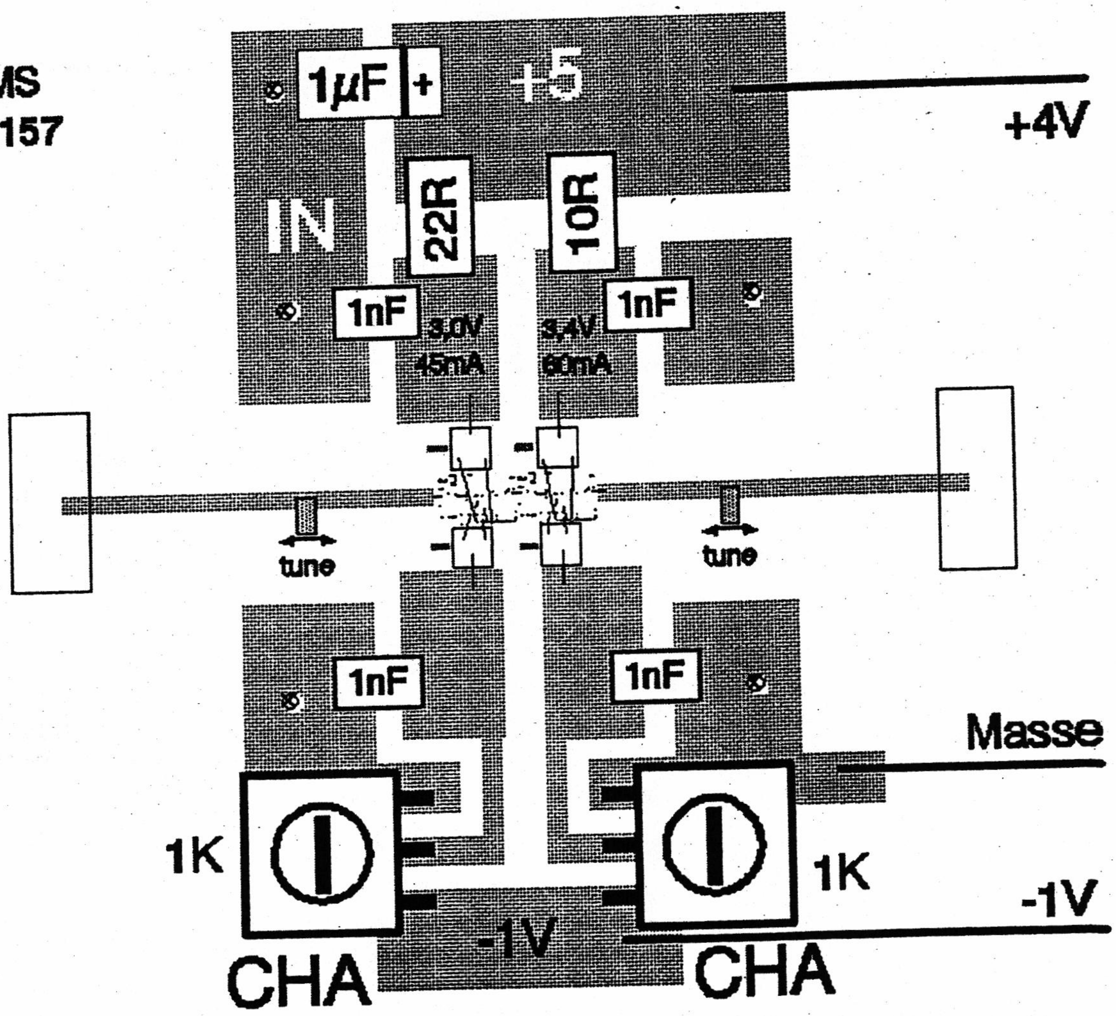


47 GHz Amplifier DB 6 NT 3.2001



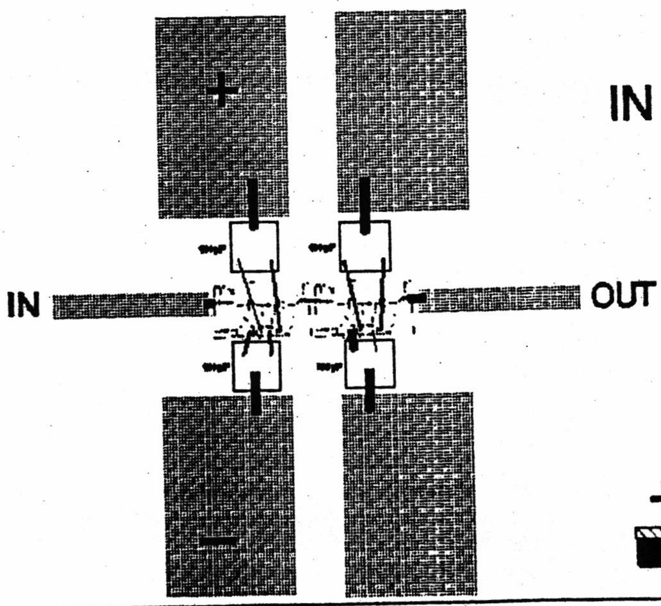
Bestück und Bondplan des Verstärkers mit 2x CGY2139X

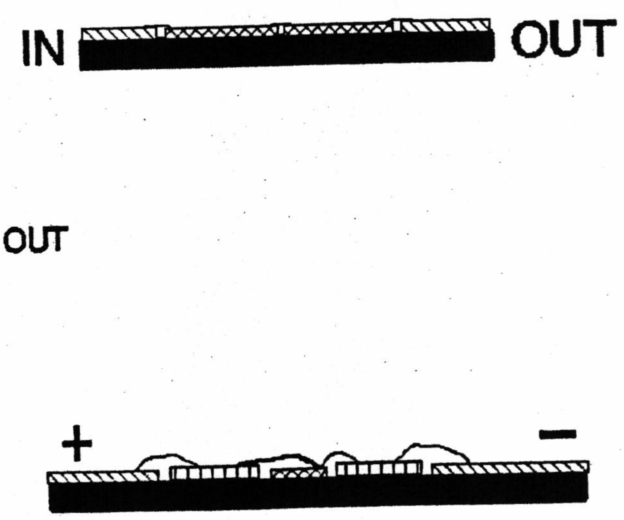
2 xUMS
CHA2157



2 xUMS
CHA2157

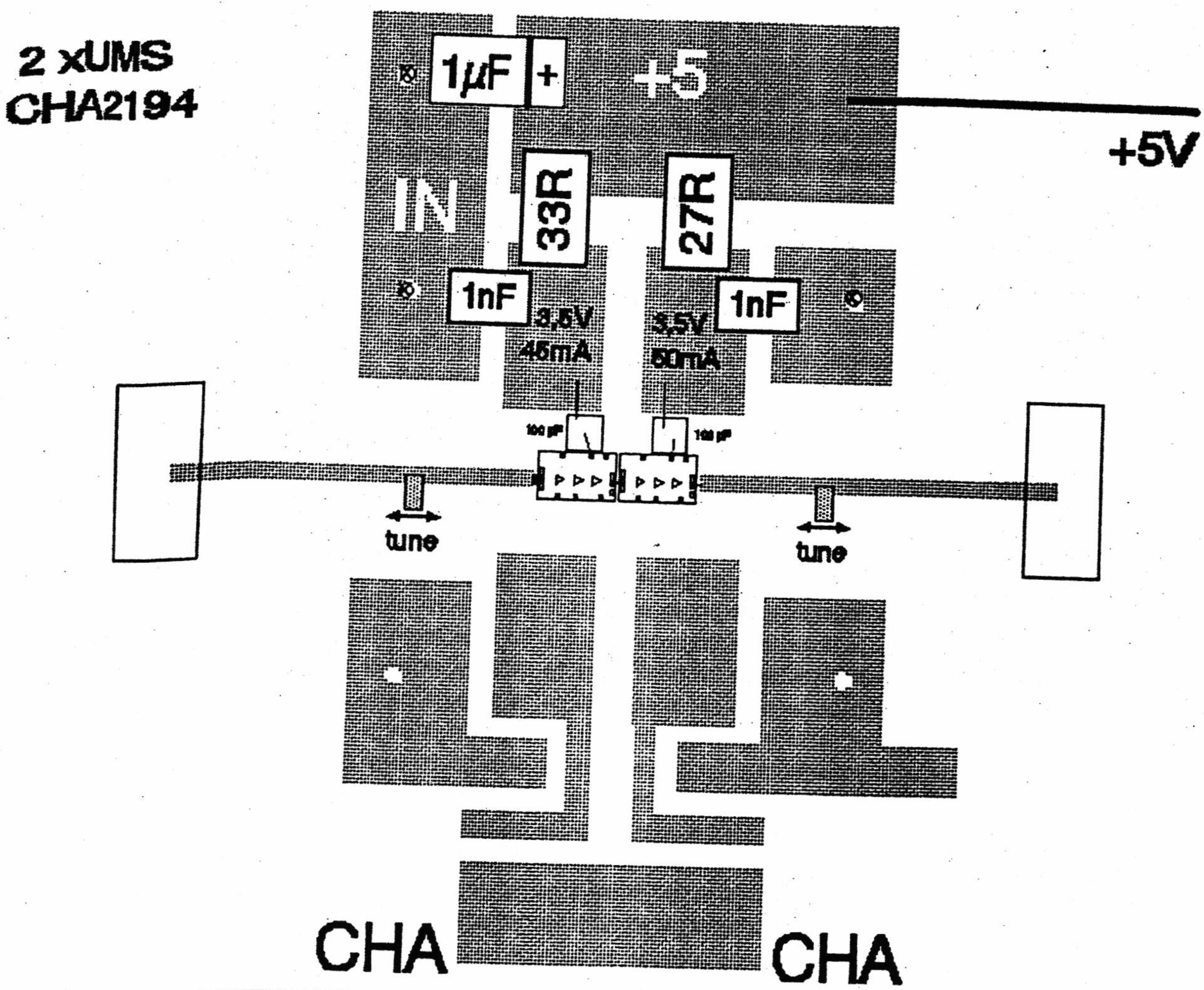
47 GHz Amplifier DB 6 NT 11.2001



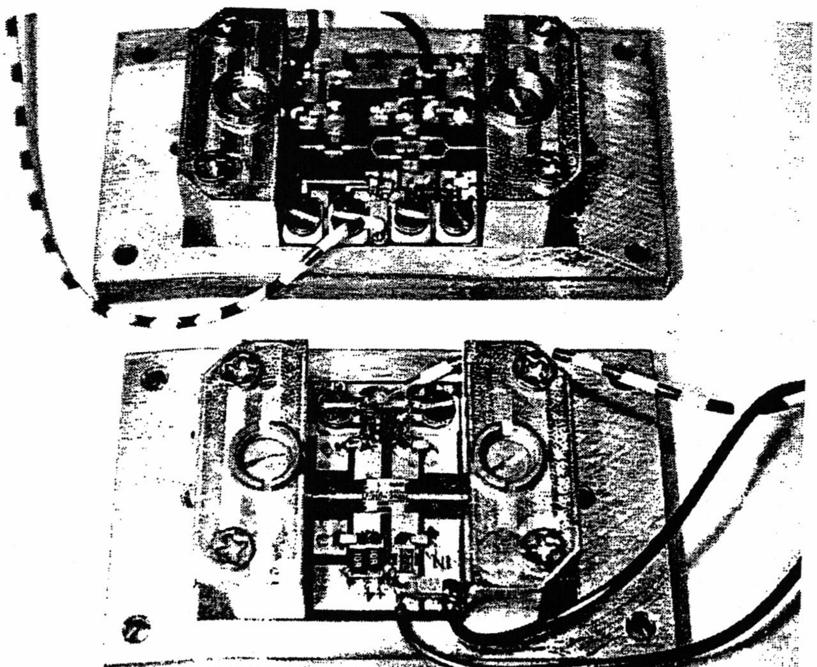


Bestück und Bondplan des Verstärkers mit 2x CHA2157

47 GHz Amplifier CHA DB 6 NT 1.2002



Bestückplan des Verstärkers mit 2x CHA2194



Verstärkers mit 2x CHA2194 parallel (oben), sowie mit CHA 3093C (unten).

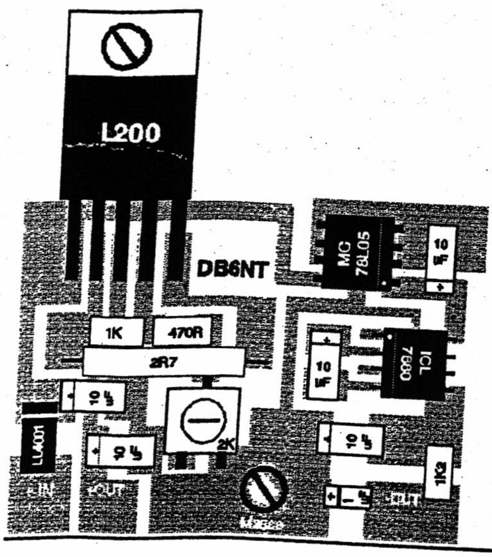
Stromversorgung

Für den Betrieb ist eine negative Versorgungsspannung sowie eine positive Drainspannung erforderlich.

Dazu wurde eine entsprechende Schaltung mit SMD -Leiterplatte entwickelt, die universell für verschiedene Verstärker verwendet werden kann.

Die mit handelsüblichen Bauteilen bestückte Leiterplatte erzeugt eine strombegrenzte Drainspannung mit regelbarer Ausgangsspannung von 4...7V und je nach Widerstandsbestückung einer Strombegrenzung von 10...2000mA. Die negative Gatespannung beträgt 5V über einen Vorwiderstand.

Arbeitswiderstände für die einzelnen Stufen sowie Gatespannungsregler befinden sich auf den HF-Leiterplatten.



Bestückplan der Leiterplatte

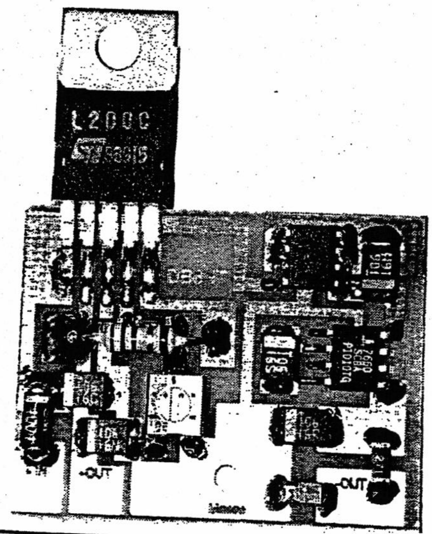
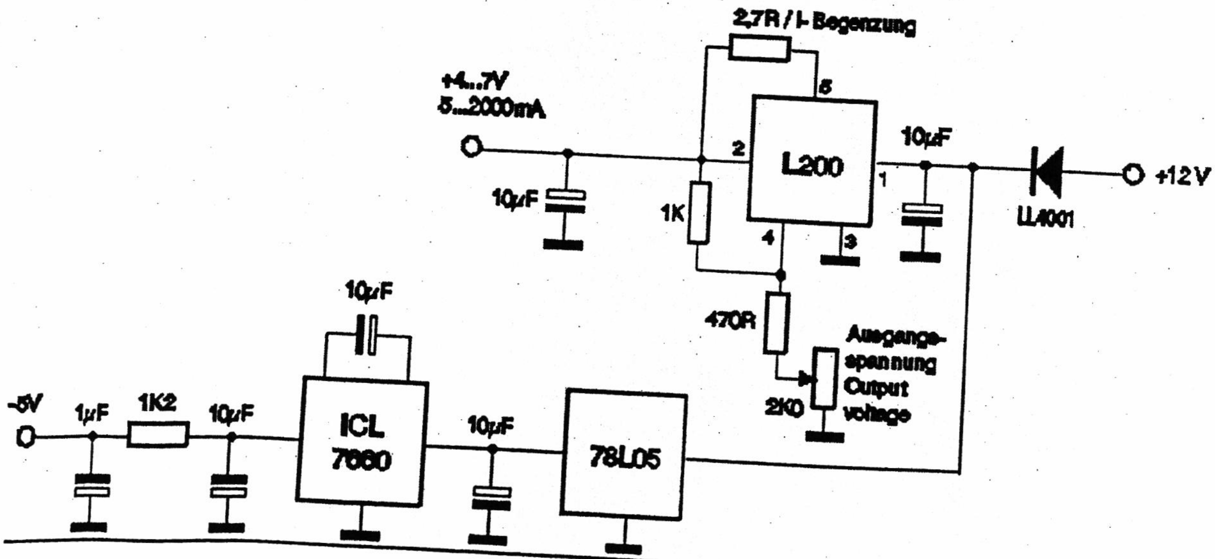


Foto der Stromversorgungsleiterplatte



Schaltplan der Stromversorgungsleiterplatte

Abgleich

Zunächst werden die Gatespannungen auf den entsprechenden Wert der IC´s, ca. –0,3V, voreingestellt. Danach wird die Drainspannung angelegt und der dem Datenblatt entnommene Drainstromwert eingestellt.

Die Arbeitswiderstände sind vorher dafür entsprechend zu dimensionieren.

Nun kann der HF-Abgleich durch Verstellen der Hohlleiterkurzschlüsse (Abstimmschrauben der Firma TEKELEC-TEMEX) und durch Anbringen von „stups" an den HF-Leiterbahnen erfolgen. Danach erfolgt der Feinabgleich mit den Ruheströmen der IC´s.

Erreichte Technische Daten

Prototypen mit je 2 Chips in Serie.

Mit den **PHILIPS** IC's (Orginal Frequenzbereich 38...44 GHz) konnte bei zwei Prototypen eine Verstärkung von **31 dB** bei einer Sättigungsleistung von **20 mW** erreicht werden. Das ergibt bei einer Steuerleistung von 25µWatt eine Ausgangsleistung von **14 mW.** Einseitenbandrauschzahl **NF** betrug bei einem Exemplar **5,7 dB** bei dem anderen **4,9 dB.** Durch die hohe Leerlaufverstärkung bei 40 GHz ergab sich eine leichte Schwingneigung, die mit Absorbermaterial zu unterdrücken war.

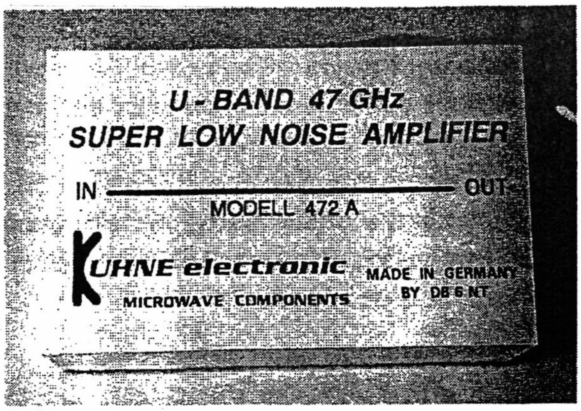
Mit den IC´s der Firma **UMS** (Original Frequenzbereich 55...60 GHz) konnte bei einer Verstärkung von **27 dB** eine Rauschzahl NF von **4,1 dB** gemessen werden. Bei einer Steuerleistung von 25µW wird eine Ausgangsleistung von **8 mW** erreicht. Die Sättigungsleistung liegt bei **37 mW!** Output. Der Abgleich im Eingang des Verstärkers war kritisch und stellt einen Kompromiss zwischen Rauschanpassung und Verstärkung dar. Dieses ist auf die schlechte Eingangsanpassung des IC's bei 47 GHz zurückzuführen (siehe Datenblatt –2-). Die angegebene Rauschzahl von 3,5 dB bei 55...60 GHz konnte bei 47 GHz nicht erreicht werden.

Mit 2 Chips **CHA 2194** (Orginal Frequenzbereich 36...44 GHz)in Serienschaltung wurde bei einer Rauschzahl von **4,4dB NF** eine Verstärkung von **32 dB** gemessen. Die Sättigungsleistung lag bei **42 mW.**

Ein mit zwei parallel geschalteten Chips **CHA 2194** aufgebauter Verstärker erreichte **65 mW** Ausgangsleistung.

Ein Leistungsverstärker mit **CHA 2194** in der Vorstufe und **APH403** in der PA erreichte bei einer Steuerleistung von 0,5mW eine Ausgangsleistung von **120mW.** Eine Version mit zwei parallel geschalteten APH403 wird derzeit aufgebaut und verspricht die **200mW** Ausgangsleistung zu überschreiten HI.

Ein weiterer Verstärker mit dem UMS Chip CHA 3093c ergab keine zufriedenstellenden Ergebnisse.



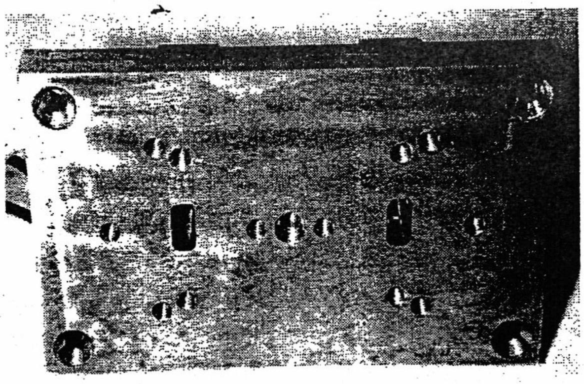
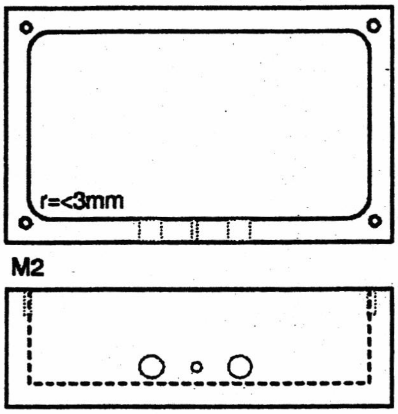
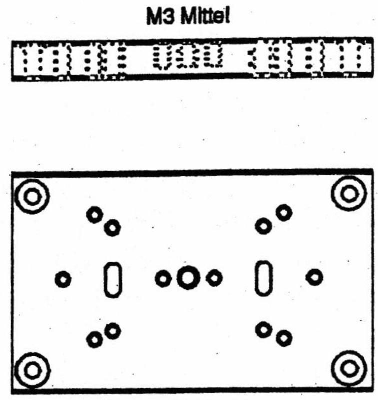


Foto: Verstärker **Foto: Rückseite des Verstärkers**





Skizze: Deckel Grundplatte

Messungen

Rauschzahl und Verstärkung wurden über einem 47 GHz DB6NT Transverter mit 2 Kreis Hohlleiterfilter nach OE9PMJ gemessen. Dazu wurde ein Noise Gain Analysator von EATON 2075B mit einer Hohlleiterrauschquelle HP Q 347B benutzt. Die Leistungsmessung erfolgte durch ein HP435B mit Powersensor Q8486A.

Zusammenfassung

Ich denke, das die erreichten Werte einen deutlichen Fortschritt für die Amateurfunktechnik im 47 GHz Band darstellen. Sicherlich wird es in Zukunft weitere interessante Verstärker IC`s geben, die noch bessere Ergebnisse bringen, doch gegenüber den bisher verwendeten Transvertern mit Subharmonicmischer (Einseitenband Rauschzahl um die 11 dB) stellt der derzeitige Stand bereits eine Rauschzahlverbesserung von über 6 dB (eine S -Stufe) dar.
Die SSB Sendeleistung erhöht sich auch um ca.30 dB. Als einzige Hürde für den Nachbau ist die Bondtechnologie zu sehen, die leider nicht zu umgehen ist.

Danksagung

Bedanken möchte ich mich bei den Firmen **PHILIPS** Tunerwerk in Krefeld und bei der Firma **RICHARDSON ELECTRONIC GMBH** für die Bereitstellung der Musterchips. Ferner bedanke ich mich bei Herrn **Gerold Henning** für die Inbetriebnahme unserer Bondanlage und die Verarbeitung der Prototypen. Der optimale Aufbau wurde unter anderem durch **Gert DG8EB** und **Hubert DG1KBF** realisiert.

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(2) Datenblatt, **UMS CHA2157 und CHA2194**

(3) Datenblatt, **VELOCIUM-TRW APH403**

(4) 47 GHz **Transverter,** DB6NT DUBUS 1.94 / Technik Buch IV

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AMPLIFICATEUR 47Ghz

Par DL9MFV

Article décrivant la construction d'un amplificateur 47Ghz . Les deux étages utilisent des puces de chez UMS , et donnent au moins 26dB de gain. L'accès à la technologie du bonding est obligatoire.

Traduction sommaire :

1) INTRODUCTION : Cet amplificateur a été réalisé pour examiner les effets non thermiques de la HF pulsée, les résonances moléculaires intervenant entre 42 et 46 Ghz. L'amplificateur convient aussi pour des applications amateur sur 47088Mhz.
2) CHOIX DES SEMICONDUCTEURS : Une alternative économique à l'utilisation de composants discrets , est l'utilisation de puces , collées sur un support , les connections étant « bondées ». Le CHA3093c de chez UMS a été choisi. Il fonctionne entre 20 et 40Ghz , mais les paramètres S laissent espérer un fonctionnement correct à 47Ghz (gain d'au moins 17.3dB).. Ces paramètres S sont mesurés directement sur le chip , mais moyennant un construction soignée , 14 à 15 dB peuvent être atteints . L'adaptation d'entrée de –11,1dB est une valeur acceptable , et une puissance en saturation de 150mW à 3db de compression est spécifiée. Voir la figure 1 : les 4 groupes de semi-conducteurs cascadés peuvent être reconnus.
3) CONCEPTION DU CIRCUIT : Une puce excite 2 autres puces en parallèle via un diviseur de Wilkinson , puis recombinaison en sortie par un autre Wilkinson. Les 3 puces sont identiques.
4) CONSTRUCTION MECANIQUE ET ELECTRIQUE : Le boîtier est fraisé dans du laiton (60*30*9mm) puis doré. La profondeur du fraisage est de 4.8mm , l 'ensemble est connectorisé en K (2.4mm). (Fig2). Le substrat est en céramique fine (nitride d'aluminium Er=9.0) d'épaisseur 0.254mm. Les lignes microstrips ont été connectées aux surfaces du chip via un espaceur coplanaire . La bonne dissipation thermique du nitride d'aluminium permet de coller les chips directement sur la surface. . Le bonding a été réalisé par thermo-compression en utilisant des fils d'or de 17.5um. Les chips , condensateurs et substrats ont été collés à la colle d'argent durcie à 150°C (fig3 et 4 pour les détails de la construction).
5) RESULTATS : Pour 360ma de courant drain par chip (0,5-0,6V de polarisation grille). Un radiateur est nécessaire (4W dissipés). A l'origine l'amplificateur a été essayé avec 200uW d'excitation , il sortait 20mW , la puissance a été grossièrement optimisée pour atteindre 80mW . Dans la sortie , une forte désadaptation a été remarquée (5.8dBde s22). Le gain est d'environ 26dB , c'est à dire 13 dB par étage , et le point de compression à –3dB est d'environ 20.7dBm. Avec l'excitation qui convient , une puissance saturée de 120mW a été obtenue. L'amplificateur est sensible à la chaleur , même en cas de boîtier modérément chaud , la puissance de sortie diminue de 10 , 20% , un radiateur généreusement dimensionné est donc fortement conseillé. . L'application d'absorbant dans l'entrée et la sortie du boîtier est nécessaire avant de fermer avec un couvercle.

Sigurd Werner, DL9MFV

Amplifier For 47GHz Using Chip Technology

The article below describes a project to construct an amplifier for the 47GHz microwave band. The two stage amplifier uses semiconductor chips from United Monolithic Semiconductors, S.A.S. and gives at least 26dB gain. Anyone actually constructing this power amplifier must have access to bond technology.

1. Introduction

The non-thermal effects of pulsed high frequencies are being examined as part of certain research projects [4]. Of particular interest are the effects of high frequencies on the activity of protein based bodies (enzymes). Since molecular resonances are to be expected in the range from approximately 42 to 46GHz, the experiments began in this range.

In addition to a generator and measuring equipment for this frequency range, we needed (among other things) a good stable power amplifier. This article shows that the amplifier designed and assembled is also suitable for use on the amateur radio frequency of 47,088MHz. This description could prove a stimulus for people with projects of their own.

2. Selection of semiconductors

The use of discrete semiconductors in the GHz range referred to is always very expensive for radio amateurs and is combined with considerable design expenditure. An alternative is the use of suitable semiconductor chips, which are glued onto a carrier material, and their connections bonded.

Unfortunately, there are no ready made chips for this frequency range, so some DIY work is called for.

After an examination of the data sheets from various chip manufacturers, the CHA3093c from UMS (United Monolithic Semiconductors, S.A.S.) was chosen.

In the data sheet, this chip is specified for frequencies between 20 and 40GHz, but when the S parameters were studied, they were listed for up to 50GHz, the amplification value for 47GHz was found to be at least 17.3dB.

However, this applies only to measurements on the wafer but with a good construction, values of approximately 14 to 15dB can be attained. The input matching is -11.1dB, which is an acceptable value. A saturated power of 22dBm, approximately 150mW, is specified (3dB compression). Fig. 1 shows the chips, greatly magnified. The four groups of cascaded semiconductors can be clearly recognised.

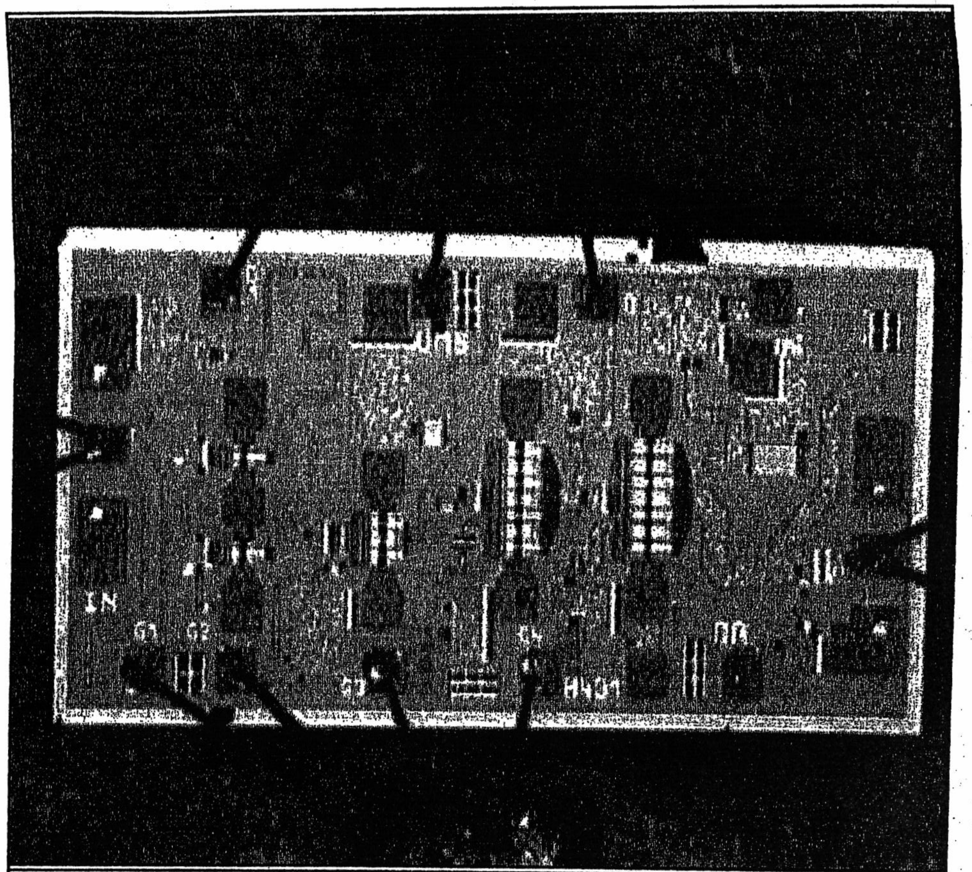


Fig. 1: Magnified illustration (x 120) of CHA 3093c chip from UMS.

3. Circuit design

The design is relatively simple. A driver chip feeds two chips in parallel through a Wilkinson divider. The power is combined again through a second Wilkinson divider. The same chips (type CHA 3093c) are used for all three devices.

4. Mechanical and electrical construction

The housing for the prototype was milled from brass (60 x 30 x 9 mm.) and gold plated. The depth of the cavity is 4.8mm. K plugs (2.4 mm.) were mounted at the input and output of the amplifier circuit. Fig. 2 illustrates the construction of the amplifier.

The carrier substrate is a thin ceramic plate made from aluminium nitride (AlN, ε=9.0) which is only 0.254 mm. thick.

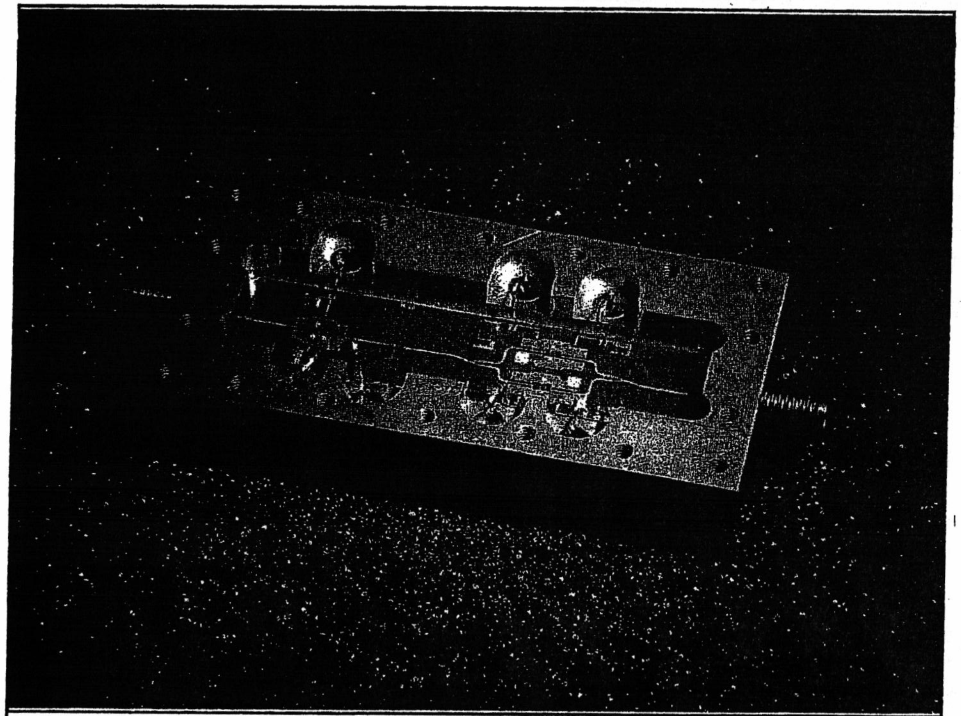


Fig. 2: Assembly of two stage microwave amplifier in gold plated milled housing; the Wilkinson dividers can be easily recognised.

The microstrip lines have each been connected to the chip surfaces through a co-planar spacer. Thanks to the good thermal conductivity of the aluminium nitride, the chips can be glued directly onto the substrate.

The power leads for the gate and the drain are decoupled using 100pF capacitors, for longer paths there are also 1nF single layer capacitors and 100nF ceramic capacitors. These are fed through the housing base using soldered in feedthrough capacitors.

The chips were bonded by means of thermo-compression (including ultra-sound support), using 17.5µm gold thread. Chips, capacitors and substrate were attached using a single component silver conductive adhesive [2] hardened at 150°C. Figs. 3 and 4 show details of the construction.

The gate bias of the first semiconductor stage on the driver chip was provided separately. Its drive is intended to test the use of the driver chip as a multiplier. A connection to the monitor diode of the chip was dispensed with for the pototype.

5. Results

The drain current per chip (at 3.6V) was set at 360mA. This requires a negative gate voltage of approximately 0.6 - 0.5Volts. A heat sink is necessary for continuous operation, since the power consumption is almost 4W.

The amplifier was initially driven using a CW signal (47,088MHz) of 200µW. The power level of approximately 20mW

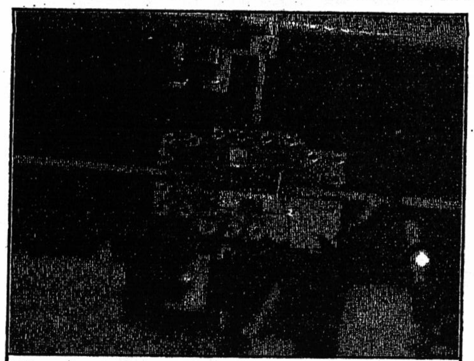


Fig. 3: Details of driver assembly.

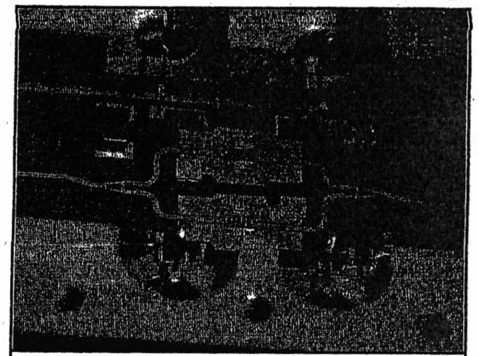


Fig. 4: Details of second stage with parallel wired amplifier chips.

measured at the output which could be raised to 80mW by rough optimisation. In the output area of the chip there was a marked mismatching (the S22 parameter is only 5.8 dB!).

The calculated amplification is approximately 26dB, i.e. 13dB per stage. The -3 dB compression point is at approximately 20.7dBm.

With suitable drive, a saturation power exceeding 120mW can be attained (Fig. 5). This means that the values specified in the data sheet were not attained. This applies, in particular, to the saturation power reached for one chip of only 17.8dBm. This could be because the semiconductors are designed for pulsed mode operation.

The amplifier is particularly sensitive to heat, even with a moderately warm housing, the output drops by 15 to 20%. A generously dimensioned heat sink must therefore be used. To counteract waveguide effects, absorption material should be applied in the input and output areas before the metal cover is fitted.

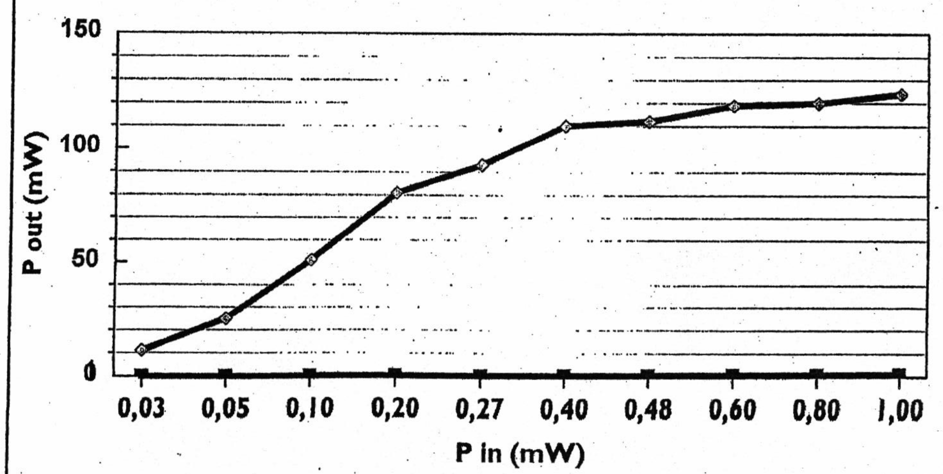


Fig. 5: The output of the amplifier plotted against the driving power, measured with a CW signal at 47088 MHz.

6. Outlook and acknowledgements

This article indicates the options for modern chips, and is intended to act as a stimulus for further experiments.

Some other interesting types of chip have recently come onto the market, these are just waiting to be tested. The price of a chip is somewhere around one Euro, depending on the source of supply. At the VHF/UHF Congress in Munich at the beginning of March, Michael Kuhne (DB6NT) introduced a project for a 47GHz preamplifier. A particularly low noise chip is used, type CHA 2157 from UMS [3].

In conclusion, I would like to thank several helpful people who have supported me in word and deed, namely Konrad Hupler (DJ1EE), Walter Ludwig (DL6SAQ), Mrs. Astrid Habel (Technical University, Munich) and Mr. Wilhelm Hohenester of Rhode & Schwarz, Munich.

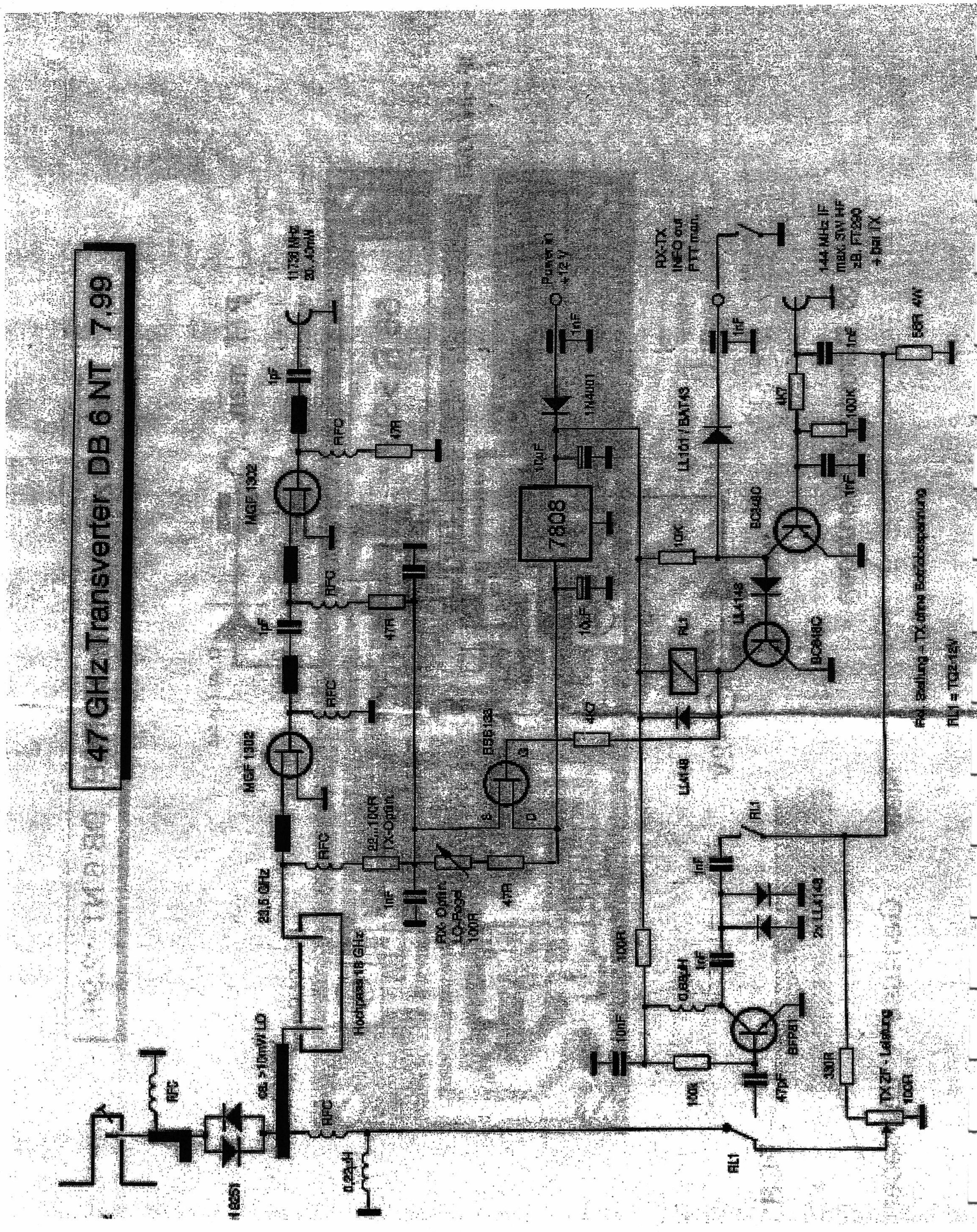
7. Literature references

[1] Data sheet from United Monolithic Semi-conductors, S.A.S.; Ref.: DSCHA30930207, 26. 7. 00

[2] Technical Data Sheet, Ablebond 84-1 LMI from Ablestik

[3] Michael Kuhne, DB 6 NT Manuscript for VHF / UHF 2002, 14th Congress, Munich 2002

[4] Institute for Physiological Chemistry of University of Munich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RX- Optim.
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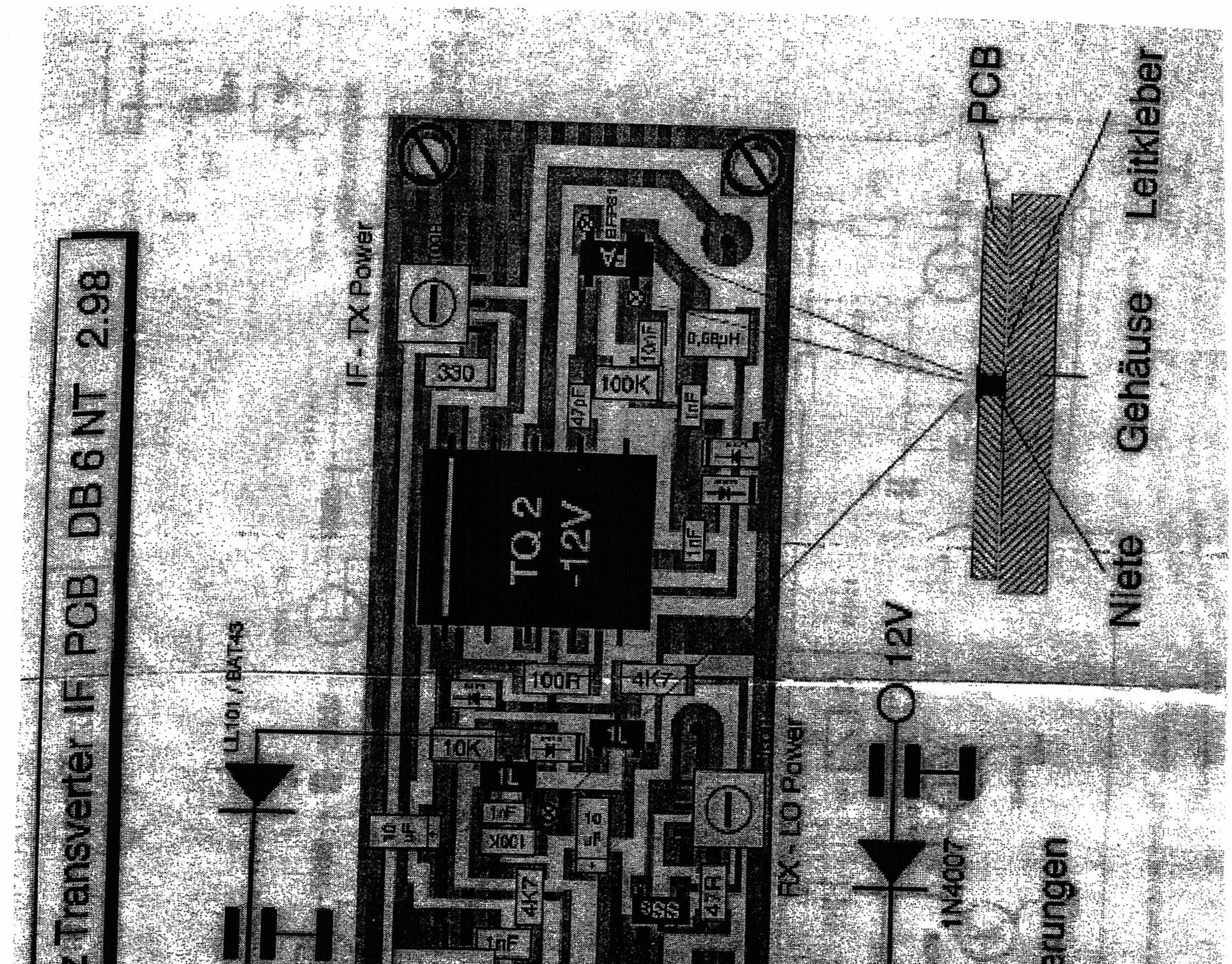

47 GHz Transverter IF PCB DB 6 NT 2.98
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IF - TX Power
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RX - LO Power
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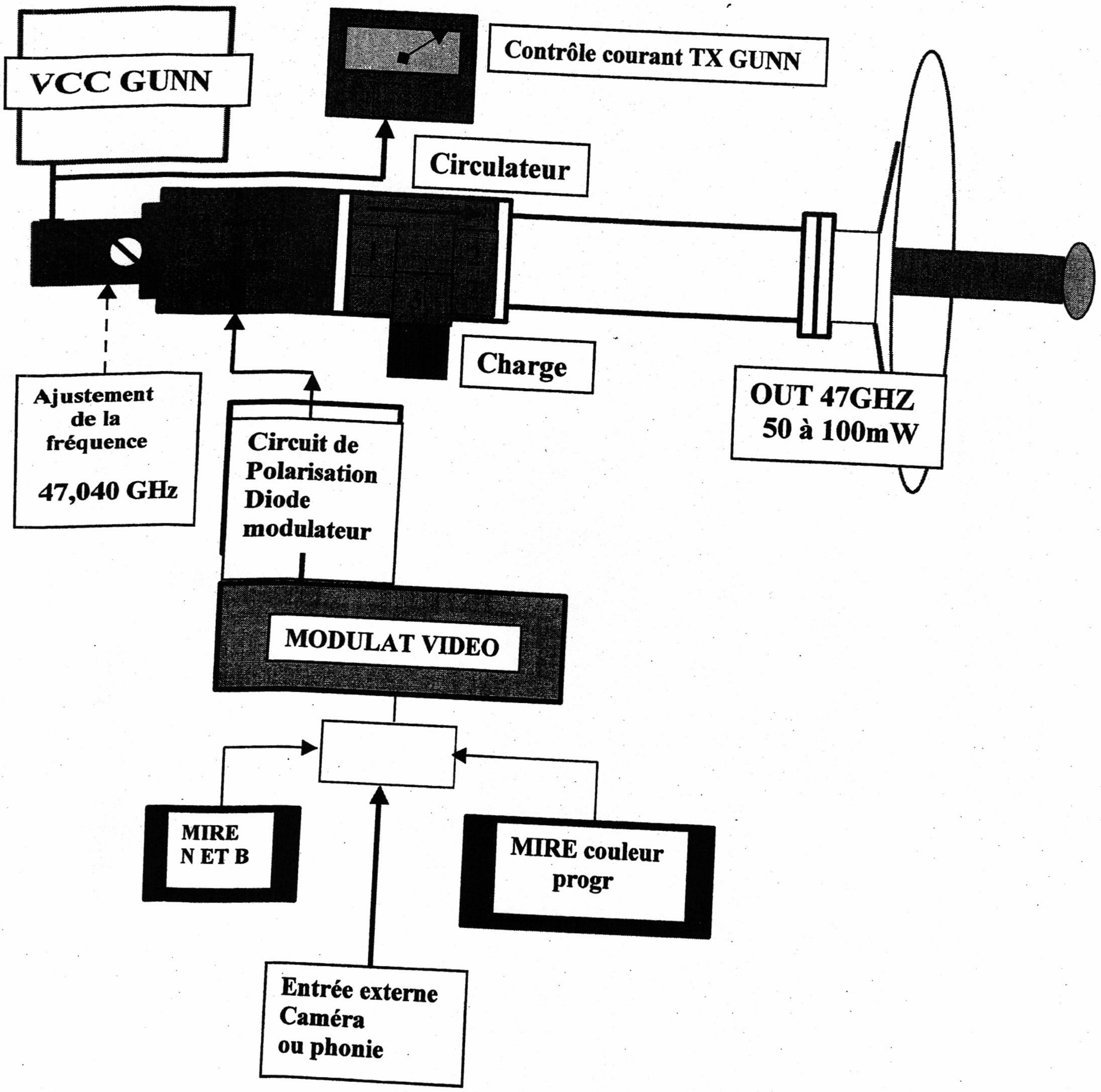
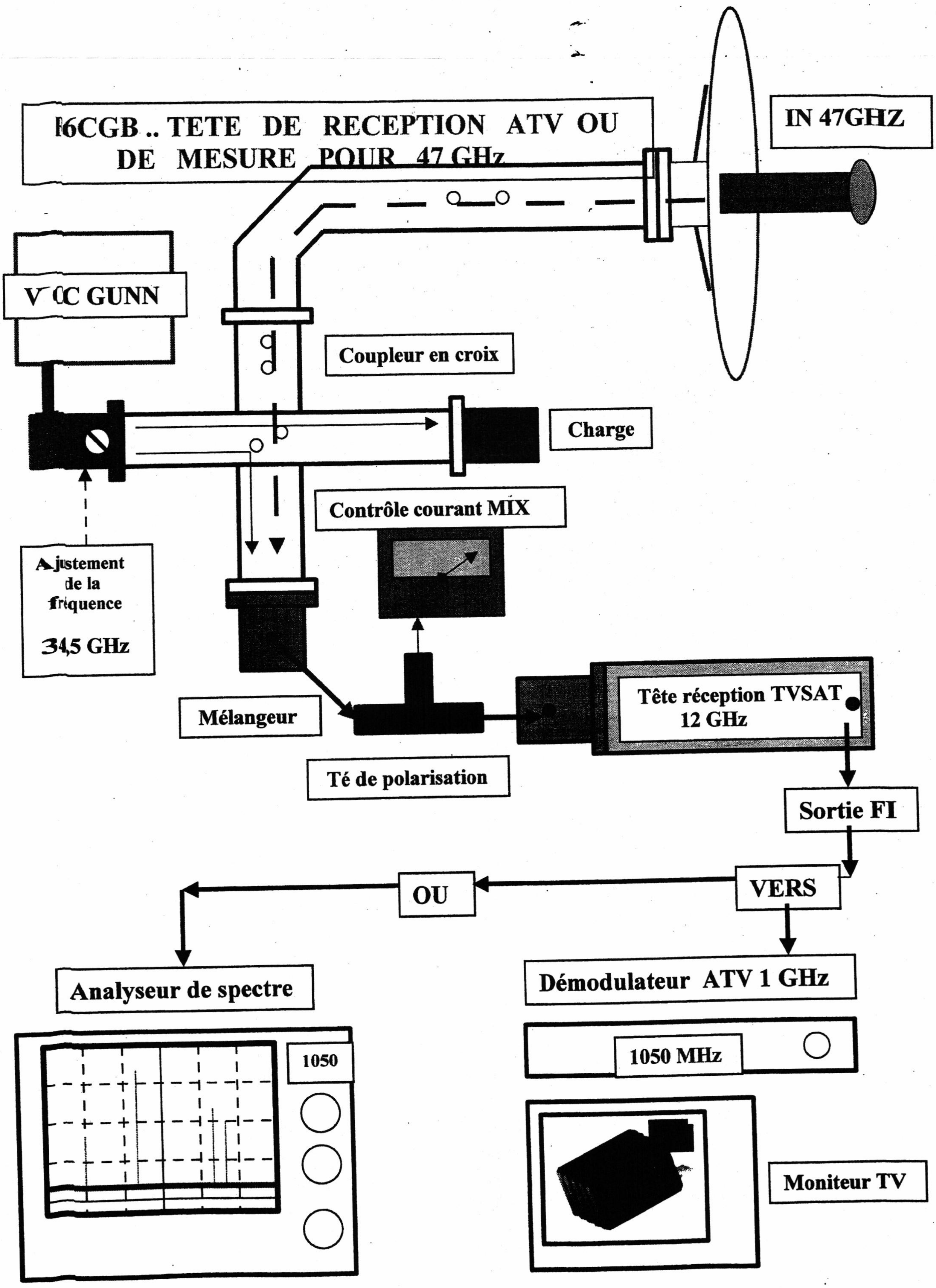
F6CGB EMETTEUR 47GHz ATV ou TELEPHONIE FM

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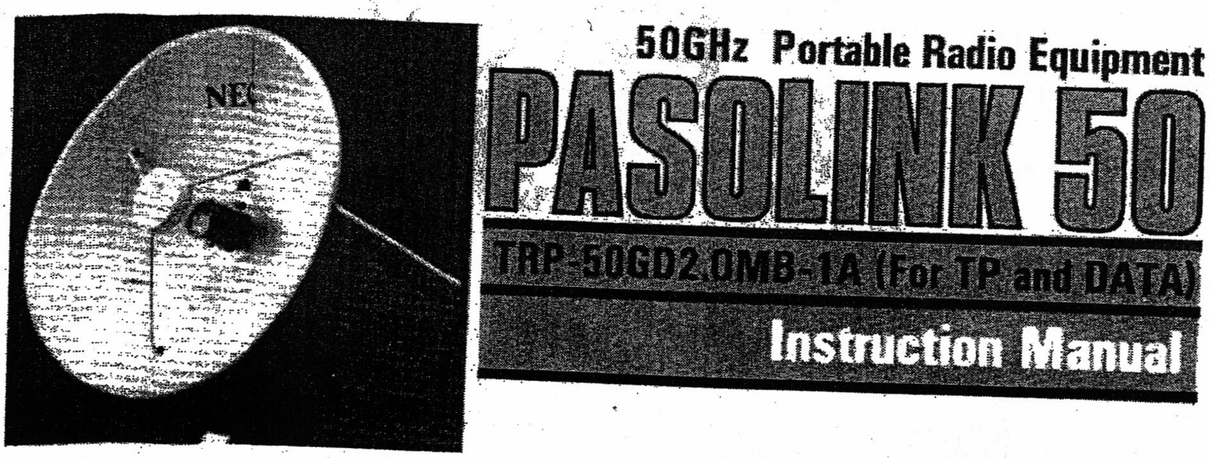
Converting the NEC PASOLINK Transceiver to 47GHz

David Robinson WW2R, G4FRE

NEC



Introduction

The NEC Pasolink TRP50GD2.0MB-1A 50GHz portable radio equipment was produced around 15 years ago to provide a full duplex 2.048MB digital and an anologue audio channel for point-to-point links at around 50GHz. It had a 500MHz transmit/receive split. The frequencies covered were 50.44 to 50.62 and 50.94 to 51.12GHz. The RF unit is approximately 5" x 9" x 7". I acquired my pair of transceivers in a "capital reduction" sale in the UK, however, in the last few years they have appeared on the surplus markets in France and I have seen them in Eastern USA (KY and FL), so it was decided it was time to describe my conversion attempts to put them on 47GHz.

Original configuration

The original configuration of the unit is shown in Fig 1. A DRO puck is used as the main frequency-determining element of the transceiver. It is used with an NEC power device to generate around 100mW at 12.775GHz. This is then fed through an isolator to a diode multiplier which after filtering generates 15mW at 51GHz. Modulation on transmit is done by FMing the DRO. The transmit signal is fed to the antenna via a circulator. Some of the transmit power is reflected to the Rx port of the circulator and is fed to a receive mixer which uses a diode. The claimed noise figure is 15dB. The first IF at 500MHz is fed through a bipolar IF amp to a second mixer which converts to a second IF at 70MHz where de-modulation takes place. The equipment is powered from 48V, positive ground which, via DC to DC converters supplies the required plus and minus voltages for the equipment.

Three antennas are supplied with the unit with gains of 12,20 and 40dB. This is achieved by having a basic 10mm horn of 12dB gain, fitting an adaptor over it to make it a 25mm conical horn of 20dB and finally using this setup to feed a 300mm Cassegrain fed dish for 40dB gain. Not having a 50 / 47GHz antenna test range it was assumed that the antennas work satisfactorily at the lower frequency.

Conversion options

The easiest option was to use the pair of Pasolink as a duplex WBFM rig on 47088 MHz, as has been tried by G4DDK. To do this one would tune the DRO Oscillator of one unit down to 11.772MHz generating a transmit signal on 47088 and use a WBFM Rx at 100MHz connected to the IF amplifier. The DRO Oscillator of the other unit is tuned to 11.797MHz generating a transmit signal on 47188 and also use a WBFM Rx at 100MHz connected to the IF amplifier. The problem with this scheme is that it could only work its duplex partner and be unable to work 47088MHz transverter stations. This scheme would only be feasible if the DRO oscillator could be tuned down 1GHz to around 11.8GHz. There is a tuning screw above puck, but this only moved the frequency about 100MHz, not enough, neither was application of bath sealant to the puck (as per a WA5VJB suggestion). The only real option was to replace the puck with a lower frequency one, but after much fruitless searching for one, this option was rejected.

The frequency response of the bipolar RX IF Amplifier was measured with 50 Ohm input/output; the results are shown in Table 1. From this it was decided that the ideal receive IF would be 432MHz.

Some attempts were made to make the transmit diode multiplier a sub harmonic mixer by applying 11.8GHz LO at +17dBm and 10dBm of IF. (following the W0EOM rule of thumb "don't hit any mixer diode with more than a total of +20dBm") Unfortunately the output was very low, around (-30dBm) so it was decided to keep the diode as a multiplier generating its massive +10dBm output on transmit and use the original mixing scheme with a 432MHz IF shown in Fig 2 on receive. The disadvantage of this approach was that two local oscillators, separated by 432MHz would be needed; requiring two switchable crystal controlled 11GHz local oscillators. On transmit one oscillator on 11.772Mhz would multiply to 47088 at +10dBm, keying this oscillator on/off would supply the modulation. The second on 11664MHz would generate the LO at 46656MHz on receive allowing the use of a 432MHz IF. A power of around +19dBm would be needed at 12GHz to allow a safety margin to avoid overdriving the irreplaceable diode.

A few options were considered for the 11.7GHz oscillators. PLL bricks were too noisy, too big and consumed too much current from the voltage inverter. The DB6NT MK3 oscillator would be ideal on size and 12V operation grounds, but I had heard no successful reports of anyone moving them very far from their nominal 12.1GHz operating frequency. I therefore reverted to the G4DDK004 2.5GHz oscillator (1) and G3WDG009 times five multiplier (2) module combination, which had been used successfully in many applications before (3). These were fairly large but it was discovered that a G3WDG multiplier worked equally well on both 11664MHz (G4DDK004 on 2332.8MHz with 97.2MHz crystal) and 11772MHz (G4DDK004 on 2354.4MHz with 98.1MHz crystal) so a relay could select one of two

G4DDK004 oscillators to feed a single WDG multiplier saving some space; it was intended to use the original NEC housing for the new transceiver The WDG multiplier produced +14dBm, a little short of our requirements so a 12GHz amp was needed. The deficiency was solved by retuning a WDG006 10GHz MGF1801 Amplifier to 12GHz with copper foil, which produced an output of +20dBm. The final local oscillator configuration is shown in Fig 3

Local Oscillator details

The modified G4DDK004 oscillator is shown in Fig 4. For stability the entire G4DDK004 oscillator is run off a L4710 low volt drop regulator, the original 78L09 regulator being removed and replaced with a link. Do not omit the 100uF capacitor on the L4710 output or spurious signals will abound. All the Crystals were cut for operation at 50C, to cope with Texas summertime temperatures and are fitted with BG330N murata posistors run off a 7805 regulator to maintain 50C. For an excellent description of how to use these posistors effectively see the article by Doug Friend, VK4OE (4)

The oscillator circuit (TR1 and TR2) is left running all the time to maintain maximum frequency stability. On off keying is achieved by keying the supply to a multiplier stage. Initially R16 was disconnected from the 10V rail and a VFET (IFRD9020, –50V, 0.28ohm on resistance 1W dissipation) used to key the collector voltage. Unfortunately the "carrier suppression" was only 18dB. So it was decided to key the collector supply of TR4 and TR5 by switching R16 and R20 with a FET, this supplies some 50dB of "carrier suppression" and produces an acceptable T7 signal.

Note that the "keying" circuit is also fitted to the receive G4DDK004 unit disables the RX LO on transmit to prevent spurious signals. For the same reason the Transmit oscillator is disabled on receive. The relay switching receive and transmit oscillators to the G3WDG009 multiplier is an SMA unit requiring 28V drive. To avoid having to build a 28V 100mA inverter the Down East RVD-1 relay driver board (5) is used to "pulse and hold" the relay.

Conversion Process

Before starting any conversions operation was verified. The output on 50GHz was measured on both units using an HP8563E analyser & HP11970K external mixer as being +10.6dBm. Communication between the two units was also confirmed. The opportunity was also taken (while it still worked!) to measure and record the DC Voltages feeding the RF unit and every DC connection point of the multiplier/receive mixer assembly. This would allow the power supply requirements of the modified units to be evaluated. It was found that the RX IF amp ran off +10V and that a negative bias of around –3.5V was applied to the multiplier diode to improve efficiency. These voltages could be supplied very easily off a 12V supply, allowing the existing volumous NEC PSU module to be discarded. The circuit of the PSU to generate the negative diode bias is shown in Fig 6. The WW2R014 PCB originally used for the Qualcom 10GHz PSU board (6) was modified for this application. The board is mounted on the inside of the front panel.

Remove and discard all the PSU and Demodulator PCBs, but keep all their associated mounting hardware, it will be used later. The 9 screws on the top and the 4 screws underneath the multiplier module are removed, allowing the innards to be modified. Firstly the DRO puck is smashed and the wires feeding the power oscillator are removed. NEC very conveniently has mounted an SMA connector on the module to allow the 12GHz DRO frequency to be measured and set. By application of a small piece of copper foil this connector can be connected to the input of the isolator instead of the output of the puck oscillator. The 20dBm of 12GHz is then fed to the multiplier through this point. The feedthrough nearest the multiplier output is the multiplier diode bias connection; the wires to the other 3 feedthroughs on the underside of the mixer are disconnected, as they are no longer needed.

The RX IF appears on a SMB connector on the output of the brass box containing the IF amplifier A lead was made to connect this to a BNC socket on the back panel for the 432MHz receiver. The receiver diode bias preset is accessible through a hole close to the output connector.

A piece of Aluminium, the same size as the discarded PSU module is attached where the PSU module used to be. On the side away from the front panel the two G4DDK004 oscillators are mounted on edge, they were fitted with right angled SMA female connectors. Each oscillator has an SMA male barrel and an SMA right angled SMA male to female adaptor allowing both oscillators to be connected directly to the SMA relay. On the other (front panel) side of the Aluminium is mounted the RVD-1 unit, the WDG009 multiplier and the WDG006 amplifier. The output from the G3WDG006 amp is connected to the input of the multiplier with a short piece of semi rigid coax with right angled sma connectors on each end; straight connectors cannot be used as the unit cannot be reassembled into the case.

Power supply switching between receive and transmit is accomplished with a 4pole 4way switch, as shown in Fig 5. This switch also routes the key jack into circuit on transmit. The key socket is a normally closed device obliviating the need for a key to test the transmitter. The fourth position is to allow fm transmission to be added at a later date. To allow easy disconnect of the switch assembly/back panel from the main assembly the 9 pin 0.1" header connectors were reused.

Tune-up

Firstly make sure that the local oscillator chains are producing +19dBm at 11664MHz and 11772MHz respectively on receive and transmit. Next connect the local oscillator to the SMA port on the multiplier assembly. A power meter or sensitive detector is connected to the antenna port. With SW1 set to transmit the tuning screws on the multiplier up to the circulator, the circulator matching screws and the multiplier diode bias pot are adjusted for maximum output, typically 10mW on 47088MHz. Next connect a voltmeter across the bias pot at the input to the IF amp with the pot set to maximum resistance. Switch to receive and tune the screws between the circulator and the receive mixer for maximum voltage reading. It was found possible to adjust the circulator tuning screws to reduce the RX oscillator output to –32dBm without affecting performance.

The bias pot on the input to the IF amplifier is tuned for maximum receive sensitivity when receiving a weak signal. I used an 11.772GHz brick driving a WR18 waveguide detector at the bottom of the garden as a signal source.

Results

Frequency stability is excellent. Measuring the 47GHz frequencies using the HP8563E analyser, HP11970K mixer and a GPS locked 10MHz frequency reference showed both oscillators to be within 5kHz after warmup, even when left for 24 hours in an un-airconditioned garage.

The second Pasolink was altered exactly as the first one. A pair of Pasolinks worked the 55km path between Sanger, TX (EM13II) and Gunter, TX (EM13PK) during the ARRL Jan 2000 contest on cw with ease..A DB6NT transverter using a 43dB gain ProComm dish to compare the receive signals at one end of the link was considerably down on receive sensitivity, indicating that all the extra work in bringing the project to fruition had been well spent.

Conclusion

Hopefully the above will encourage anyone that comes across these units that they are worth the time and effort turning them into a useful receive system for 47088MHz.

References

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2. http://www.g3wdg.free-online.co.uk/product.htm
3. The Two FRE UK 142GHz Expedition 2000 www.mesh.net/~g4fre/142g.htm
4. Crystal Heaters, some useful observations. Doug Friend VK4OE. RSGB Microwave newsletter Jan 2000
5. www.downeastmicrowave.com
6. A Smaller Power Supply for the Qualcomm Omnitrak Amplifier Dave Robinson WW2R. http://www.mesh.net/~g4fre/10gpa.htm

Table 1. IF Amplifier gain characteristics

Frequency/MHz	Gain/dB
50	9
144	10
220	10
432	13
1296	8

Table 2. Components for Multiplier diode bias PSU

Resistors	Value	Caps	Value	Semiconductor	Part
R1	100k	C1	10u 25V	IC1	LT1054
R2	20k	C2	10u 25V	IC2	L4710
R3	10k	C3	10u 25V		
R4	820	C4	100u 10V TANT		
R5	120	C5	2200pF		
VR1	500 preset	C6	1u 25V TANT		

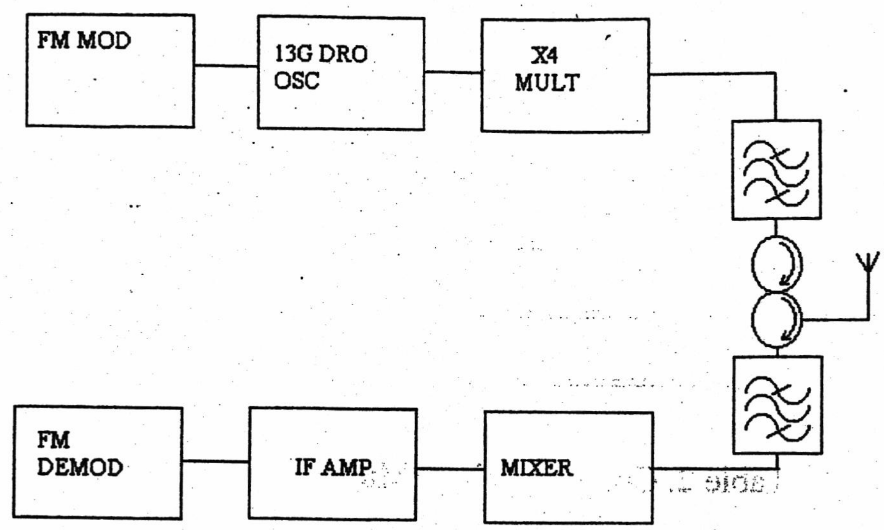


Fig 1:Original Pasolink Configuration

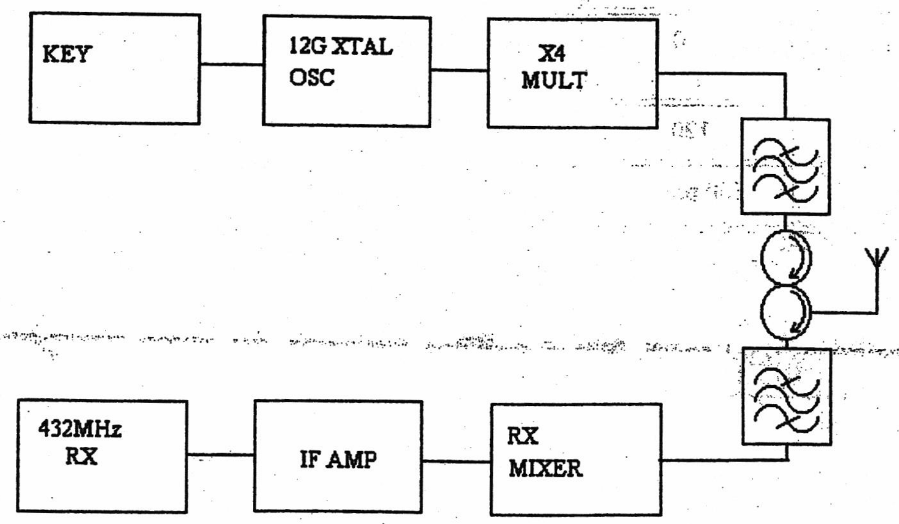


Fig 2. New configuration of Pasolink

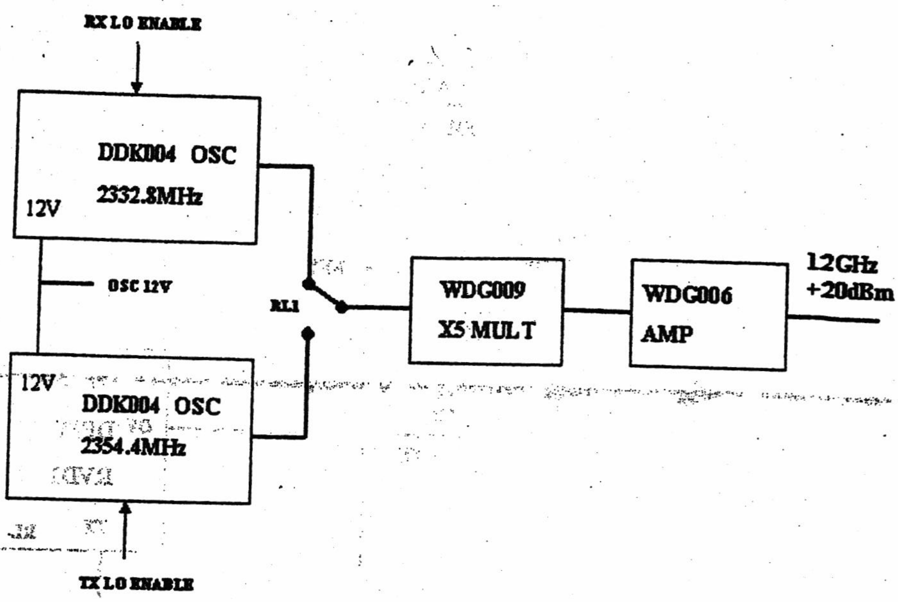


Fig 3: New 12GHz Local Oscillator for Pasolink

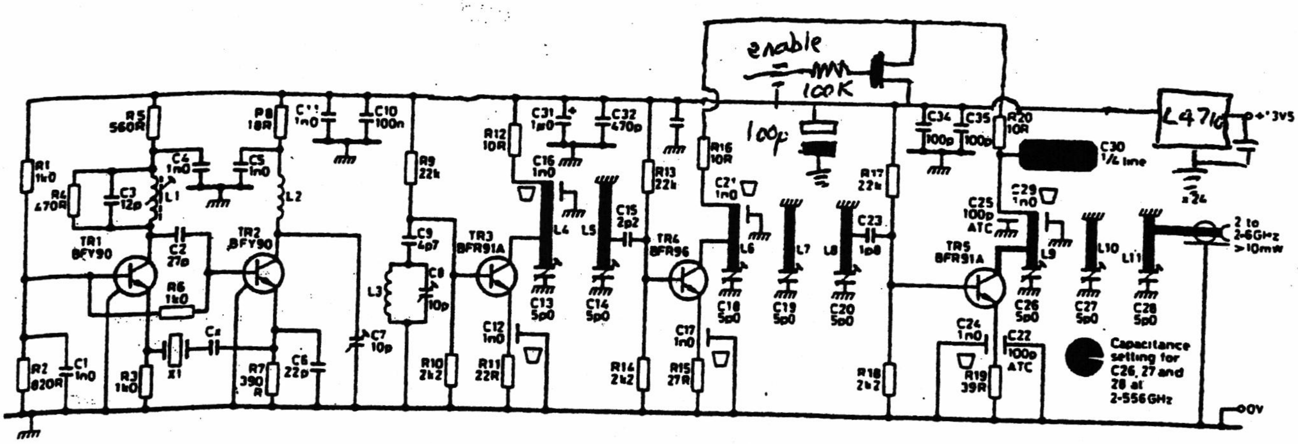


Fig 4. Modifications to G4DDK004 Local Oscillator

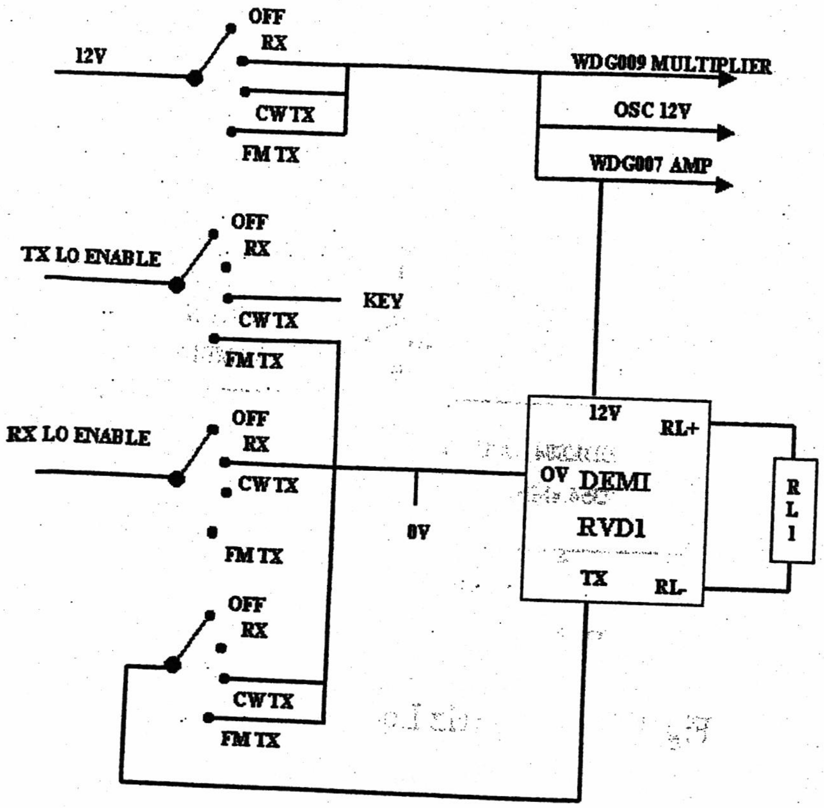


Fig 5: D.C. Switching circuit

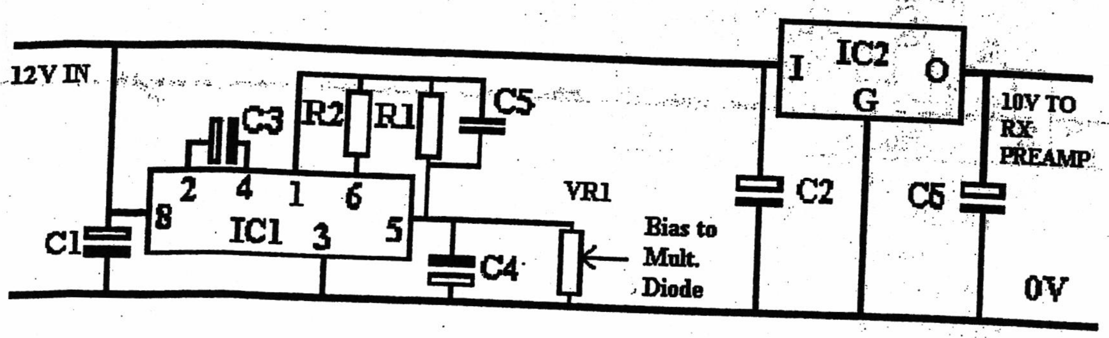
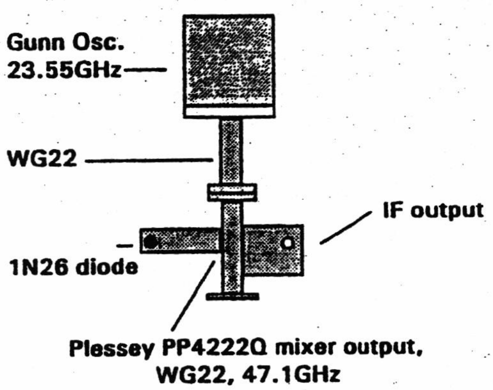


Fig 6. Mixer diode bias Circuit

Mike Parkin, G0JMI (Alton, Hants) has been extremely busy this year by working all microwave bands from 1296MHz right up to 47GHz! His Operating Ladder entry bears testimony to this. **Even more remarkable is what is possibly a record, for he worked Roy, G3FYX on all bands from six metres right up to 47GHz in one day!!** For this feat, completed on the 6th April 1997, he was /portable at Tog Hill, just 11km from Roy's home QTH in Bristol. He sends a long list of stations and locations worked from other sites, too long for these columns but we can pick out gear details as follows: 1 watt/23 ele on 23cm, 10mW/22 ele on 13cm, 100mW FM/18inch dish on 6cm, 20mW/18 inch dish on 9cm, 20mW/18 inch dish on 3cm, 1mW FM/18 inch dish on both 24GHz and 47GHz.

Mike's 47GHz station uses a Plessey doppler module (combined 23.5GHz Gunn with mixer) into an 18 inch dish with penny feed. The doppler module is in WG20 and acts as a doubler/mixer. The transmitter is a 50mW 23.5GHz Gunn in a Plessey GDO33 cavity with a modified Plessey WG22 IN26 mounted 'PP4222Q' mixer.



The 1N26 diode multiplies the 23.5GHz to 47.1GHz.

Challenging 47 GHz

By JF1AVS

I would like to explain how to build-up the signal source for 47 GHz, under the presumption that you have already had ample experiences of building 24GHz rigs. You can use these skills from 24 GHz and apply them to 47 GHz.

The fastest way to get 47 GHz output is to use 47 GHz signal source. However, GUNN oscillators and IMPATT oscillators that can output in the 47 GHz band RF are rarely sold at the surplus market and they are very expensive even if they exist on the market.

Therefore, we must build up a multiplier. I assembled a X4 multiplier and I have succeeded in obtaining 47 GHz signals by multiplying a 11.7 GHz signal.

I was careful that the outline dimensions, electrical characteristics and processing would produce a minimum of error. However, only one out of six units I made could be multiplied within the range of use for 47 GHz transmitter. (Fig-1)

The other five units worked in a very unstable way, so I had to give up using them. The results of X3 multipliers were all the same. I suppose that the deviation of component processing and also the deviation of materials have had a serious influence to the results, since the deviation of the outline dimensions of idler and impedance canceller for 47 GHz multiplier is very, very tight. (Fig-2)

I made up a x2 multiplier as my ultimate challenge and it worked with ease, and I was able to obtain 47 GHz output. However, the bottleneck in assembling x2 multiplier was obtaining multiplying devices. Shottkey-Barrier diodes in pill packages with less junction capacity have been discontinued by most manufacturers. It is becoming hard for us to obtain such type of diode(s) because the stock items of those devices are rare. However, diodes for X-band multiplying can be used as the multiplying device for a 47 GHz multiplier. So please try hard to use these diodes with hope.

How to Assemble x2 Multiplier

Two types of waveguides are necessary. WR-42 for the input waveguide and WR-22 for output waveguide. Modify the waveguides and brass block as illustrated on figure 1 and figure 2. Deviation of dimensions of each part of multiplier is very tight, so I recommend that you modify these parts with a milling machine. Be sure to tap the holes on the parts for fixing short stub tuners prior to assembling, since you cannot tap these holes after assembling.

Next, I would like to explain how to assemble these modified parts. Metal shall be assembled with solder except the connectors. It is inevitable that some amount of solder will go into the inside of the waveguide, so you must put an aluminum block of the same physical dimension as the inner space of the waveguide to stop solder invasion on the inner wall of the waveguide. The holes for screws for fixing SMA connector must be tapped at first and then fastened with an aluminum screw to prevent solder from going into the hole.

The method of soldering waveguides is to fix the two waveguides with a clamp and solder the waveguides together with a soldering iron, or by warming up the waveguides with a small gas burner. Reduce the amount of solder to a minimum for fixing the waveguide. The end of the waveguide must be about 0.2 mm out from the surface of the flange. After cooling the flange and waveguide, the surface of the flange must be completely flat, by polishing the surface of the flange with sandpaper on a flat and hard surface like a metal surface or glass.

How to Tune x2 Multiplier

Necessary item for tuning this multiplier is a 23.5 GHz exciter of 100mw output. In case of using GUNN-OSC, be sure to obtain output via an isolator. Without an isolator in the exciter circuit, the input resonance frequency of x2 multiplier does not match the output frequency of GUNN oscillator as the result of bad tuning. The VSWR becomes poor, and the GUNN oscillator maybe destroyed.

A RF power meter which can measure RF power of 47 GHz band, an ampere meter of 10-50mA range, and a 20k ohm variable resistor are needed for tuning of the 47 GHz multiplier. Wiring of the fore mentioned parts should be done as Fig-? shows, then activate the exciter and tune the stubs and short-stubs so that maximum power output can be obtained. Make sure that the bias current to the multiplier diode is not more than 10 to 20mA. Some of the diodes for X-band is below 10-20mA as bias current, if so, these diodes are not suitable for multiplying. Next connect the input port of the 47 GHz power meter with the output waveguide of the multiplier, then try hard to tune the stub tuners, short stubs, and the bias current to the diode to obtain maximum power of 47 GHz band output signal.

Other parameter to be tuned is the location of multiplying diode. Try moving the diode up and down up to 0.1 to 0.5mm to find the most optimum point. This may take a lot of time. If you can obtain more then 10mw of output, you are a real genius.

Tuning of RX Converter

This multiplier has the function of multiplying. The efficiency of converting RF to IF is low because the diode mixes RF with multiplying L/O x2. But you can build a receiver very easy with this multiplier. The receiving sensitivity is largely affected with the input level of the L/O, so please try hard to find maximum sensitivity level with injecting L/O to max 100mW.

Necessary instruments for tuning RX converter is a signal generator of 47 GHz band and a receiver of 1200mhz band. I suppose that few people have a 47 GHz signal generator. But you can substitute 23mhz GUNN-oscillator equipped with an isolator and tapered waveguide that is connected to WR-22 waveguide as a 47 GHz signal generator. You can then obtain the second harmonic wave of 23 GHz with this oscillator and it can be used as a substitute for a 47 signal generator. If you can, connect a 47 GHz filter after the tapered waveguide to reject unnecessary signals.

Then you can connect a variable attenuator of about 50 db of attenuation range after the output waveguide of this "harmonic signal generator" and calibrate with a standard signal generator. So you can obtain a perfect 47 GHz band signal generator (fig-5). Then connect a 1200 MHz IF amplifier to the mixer output of the RX converter and connect the 1200 MHz output to a spectrum analyzer or Satellite tuner with an analog meter to tune the receiving sensitivity. If you don't have any attenuators, leave some distance between the output hole of the 47 GHz harmonic signal generator and the input hole of the RX mixer unit so that the indicator of the S-meter of the spectrum analyzer or of the Satellite tuner indicates the center of the range, then trim each tuning point of the RX mixer unit.

If the indicator of the S-meter goes beyond the meter range, increase the distance between the output hole of the 47 GHz signal generator or "harmonic signal generator" and the input hole of the RX converter. The RX converter which I manufactured brought good results that it enabled me to get enough signal strength to get a colored FM-TV picture until input signal level reduced at –70 dBm.

As the RF frequency increases, it is very difficult to secure the stability of the transmitting and receiving frequency. In x20 multiplying, or x40 multiplying, if the fundamental oscillation frequency shifts at 1 kHz from the proper frequency, voice communication will be very difficult. If each of the transmitter and receiver have +/- 1 kHz deviation at the fundamental oscillator frequency, the RF communication is impossible because of too much RF frequency deviation.
Therefore, I recommend you try FM-TV as the starting of 47 GHz RF communication. Because FM-TV uses a wide bandwidth to transmit TV-signal, you can still get a TV picture and you can get a clear picture by simply tuning the parameters of TV tuner, even if the RF frequency deviates as much as 1 MHz. As the first step, build-up a 47 GHz FM-TV transceiver and confirm that it works properly, then upgrade it. In America, a lot of microwave components such as 23 GHz GUNN oscillators that can output 100mW and other components are sold abundantly, so the abundance of microwave components in American surplus market makes me very envious as a Japanese, since millimeter wave parts are very rare in Japan.

The country of Japan is small and is dotted with mountains, therefore obtaining a long line of sight path is very difficult. In the USA, there are deserts and plains that can offer long line of sight transmission paths of microwave signals. Additionally the air of the western USA is less humid than that of Japan. America has very good conditions for working long communication distances with microwaves which can enable you to achieve a long distance world record with millimeter wave. Please try hard to start 47 GHz RF communications.

The followings are FM-TV transceiver with transmitter and receiver signals with only one GUNN oscillator (Table-3) and FM-transceiver with the same circuit concept (Table-4) that I have created with surplus parts here in Japan. These transceivers are working very well. I have a lot of know-how in assembling these millimeter-wave transceivers but its sad for me that I cannot explain all the tips in a few pages. For further information, please feel free to email me, Thank you.

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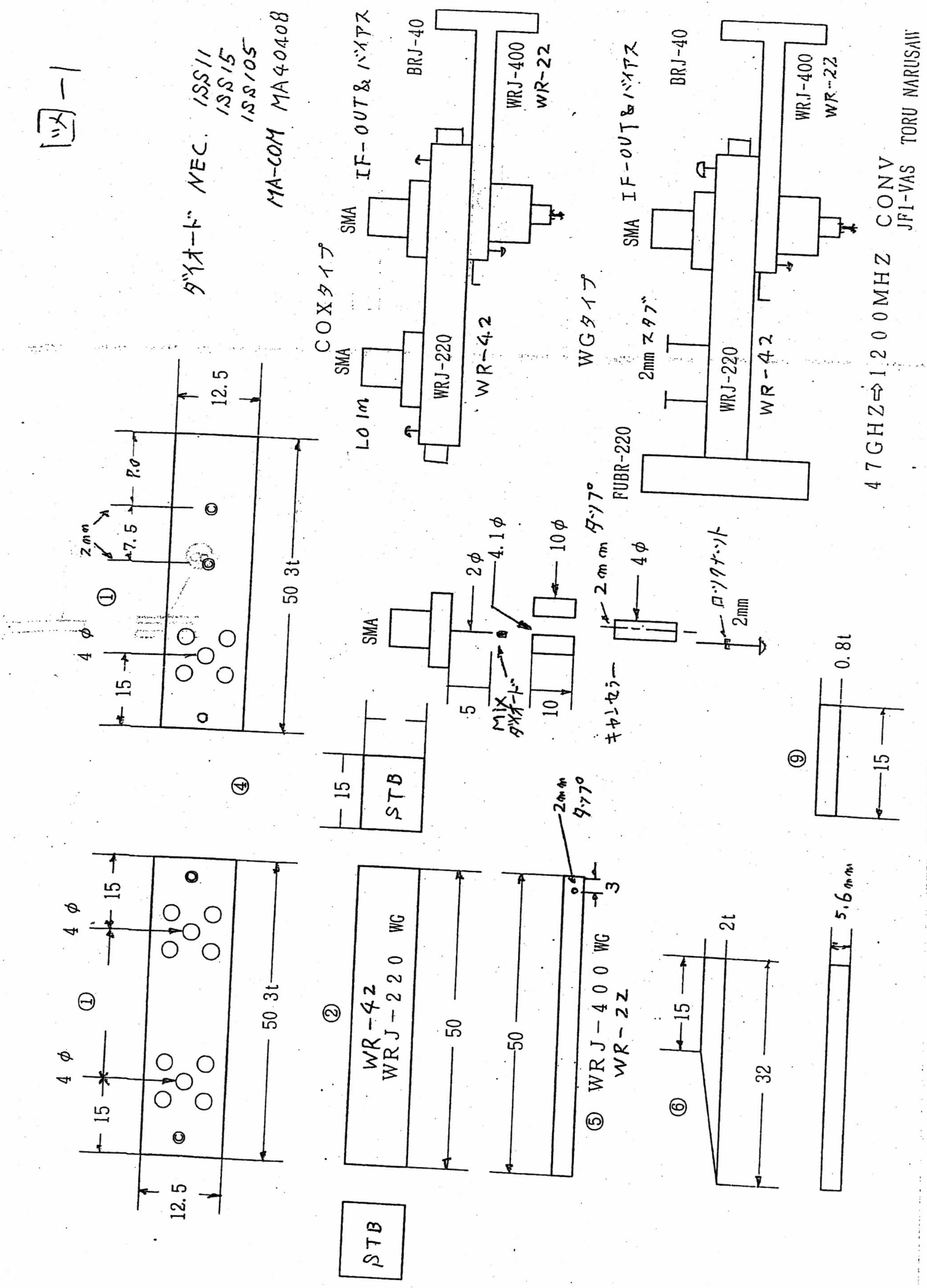
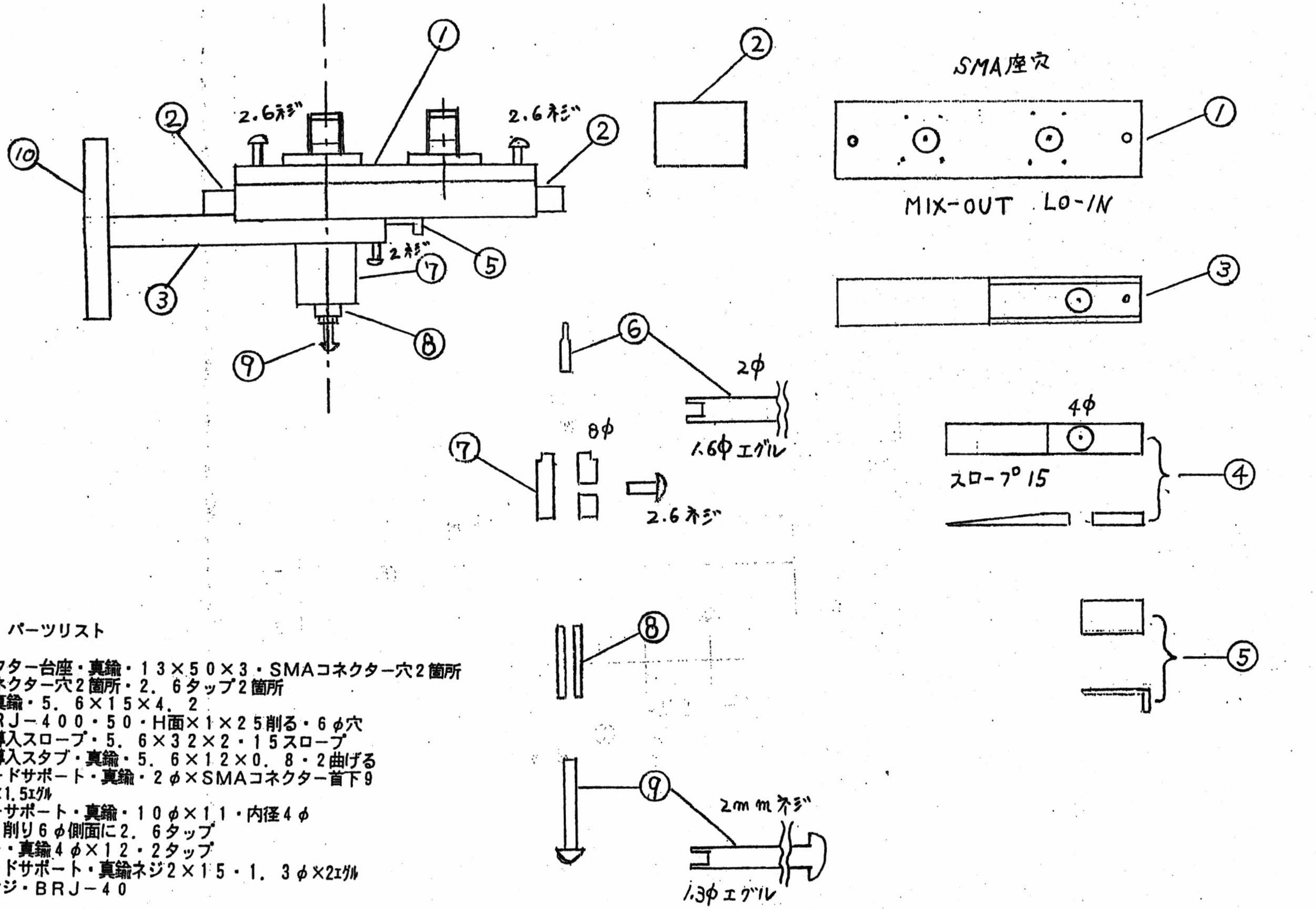


図-1
ダイオード NEC. 1SS11 1SS15 1SS105
MA-COM MA40408
COXタイプ
WGタイプ
IF-OUT & バイアス
BRJ-40
WRJ-400
WR-22
WRJ-220
WR-42
FUBR-220
SMA
47GHZ⇔12000MHZ CONV
JF1-VAS TORU NARUSAW
STB

47GHZ受信コンバーター

図-2

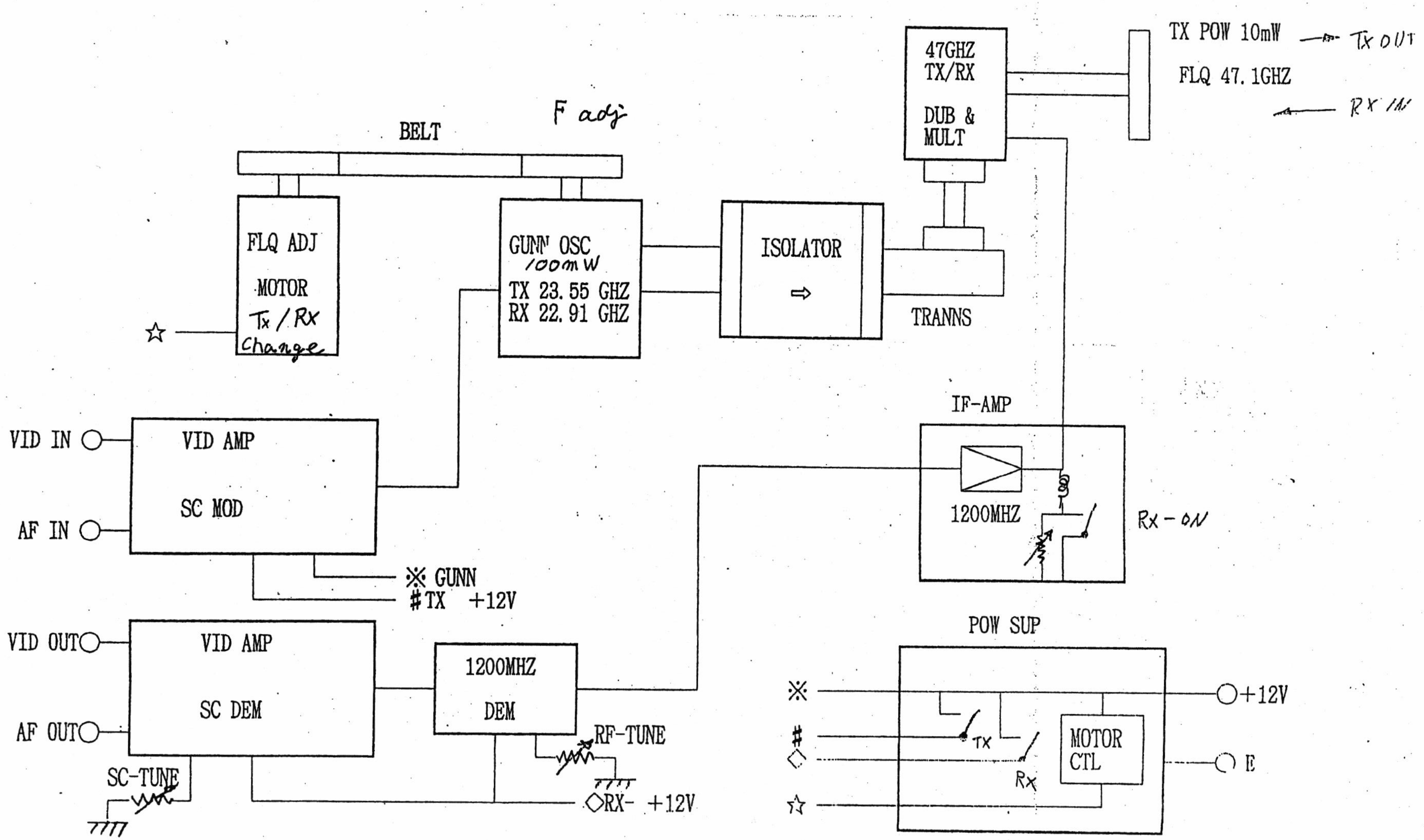


パーツリスト

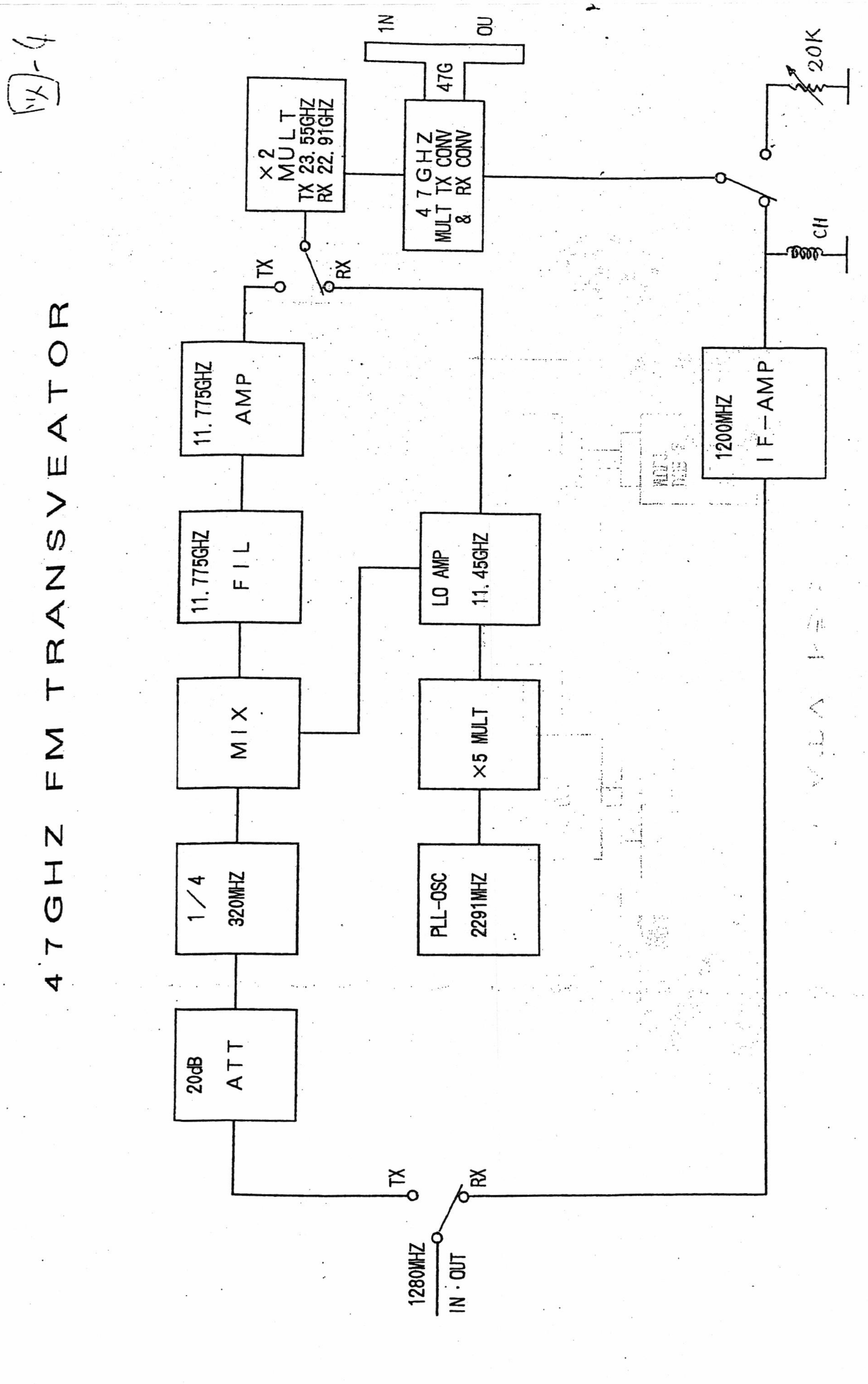
①SMAコネクター台座・真鍮・１３×５０×３・SMAコネクター穴２箇所
・SMAコネクター穴２箇所・２．６タップ２箇所
②アイドラ・真鍮・５．６×１５×４．２
③導波管・WRJ－４００・５０・H面×１×２５削る・６φ穴
④４７GHZ導入スロープ・５．６×３２×２・１５スロープ
⑤４７GHZ導入スタブ・真鍮・５．６×１２×０．８・２曲げる
⑥上部ダイオードサポート・真鍮・２φ×SMAコネクター首下９
・１．６φ×1.5エグル
⑦キャンセラーサポート・真鍮・１０φ×１１・内径４φ
・片側２×１削り６φ側面に２．６タップ
⑧キャンセラー・真鍮４φ×１２・２タップ
⑨下部ダイオードサポート・真鍮ネジ２×１５・１．３φ×2エグル
⑩バットフランジ・BRJ－４０

図-3

47GHZ−ATV トランシーバー



118


47GHZ FM TRANSVEATOR
20dB
ATT
1/4
320MHZ
MIX
11.775GHZ
FIL
11.775GHZ
AMP
TX
RX
×2
MULT
TX 23.55GHZ
RX 22.91GHZ
PLL-OSC
2291MHZ
×5 MULT
LO AMP
11.45GHZ
47GHZ
MULT TX CONV
& RX CONV
47G
IN
OU
20K
CH
1200MHZ
IF-AMP
1280MHZ
IN・OUT

119

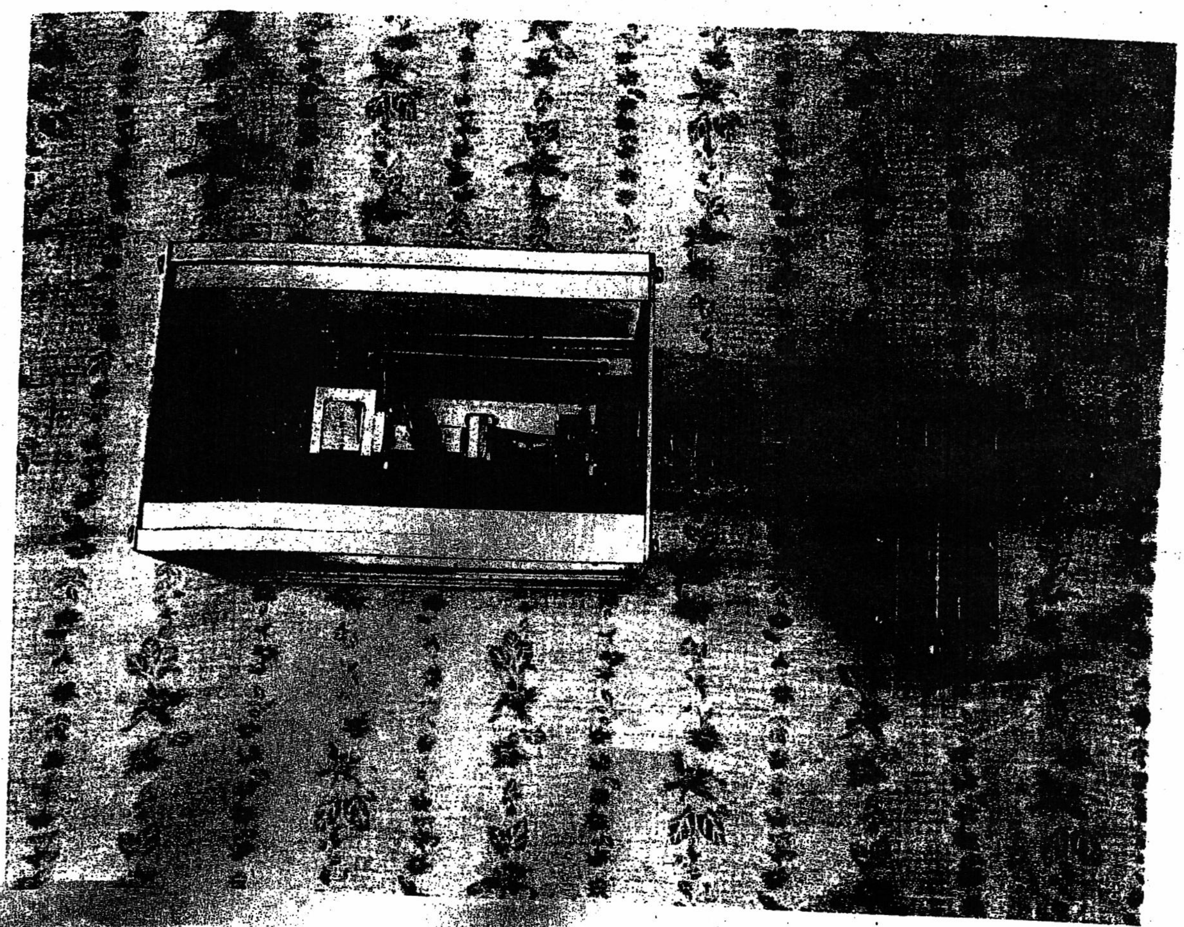
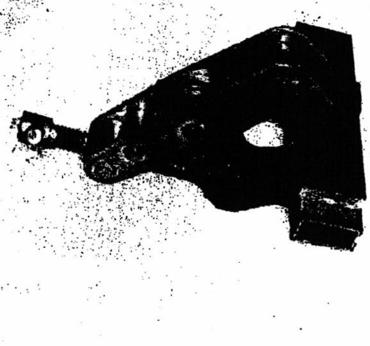


写真-5

写真-4



120

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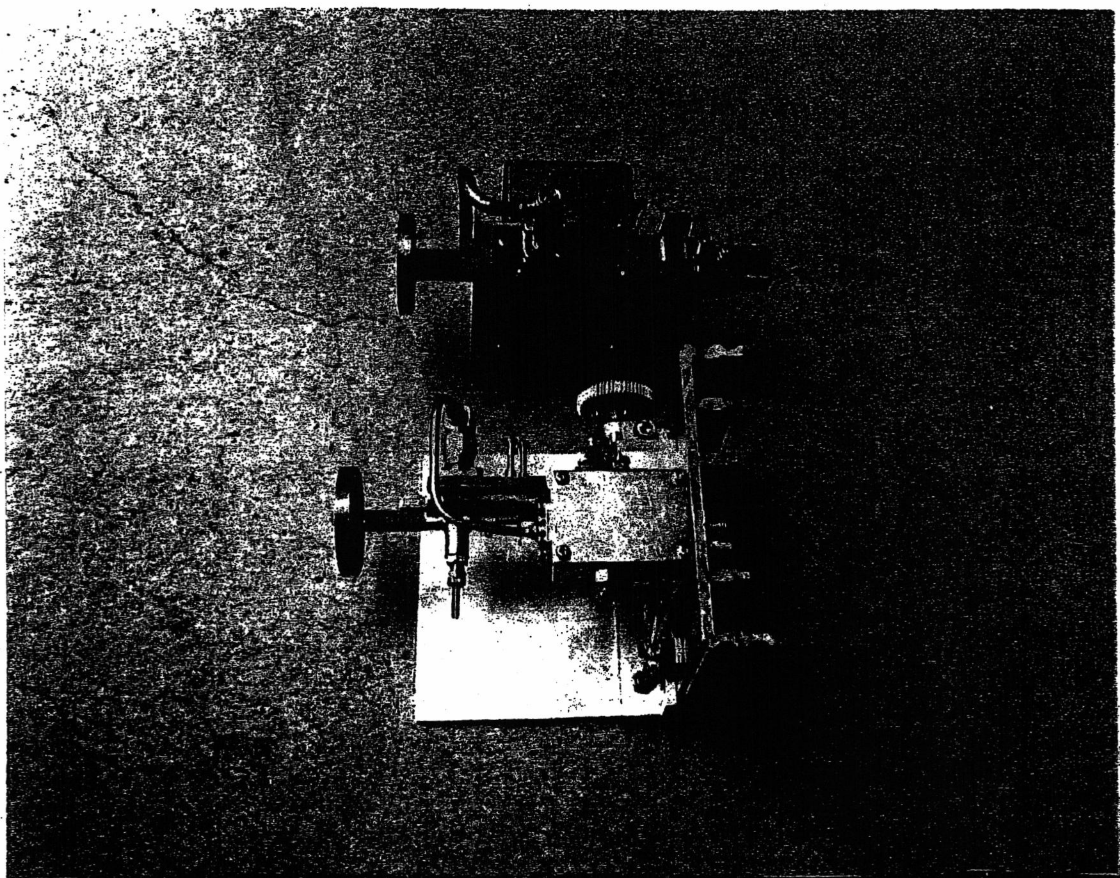
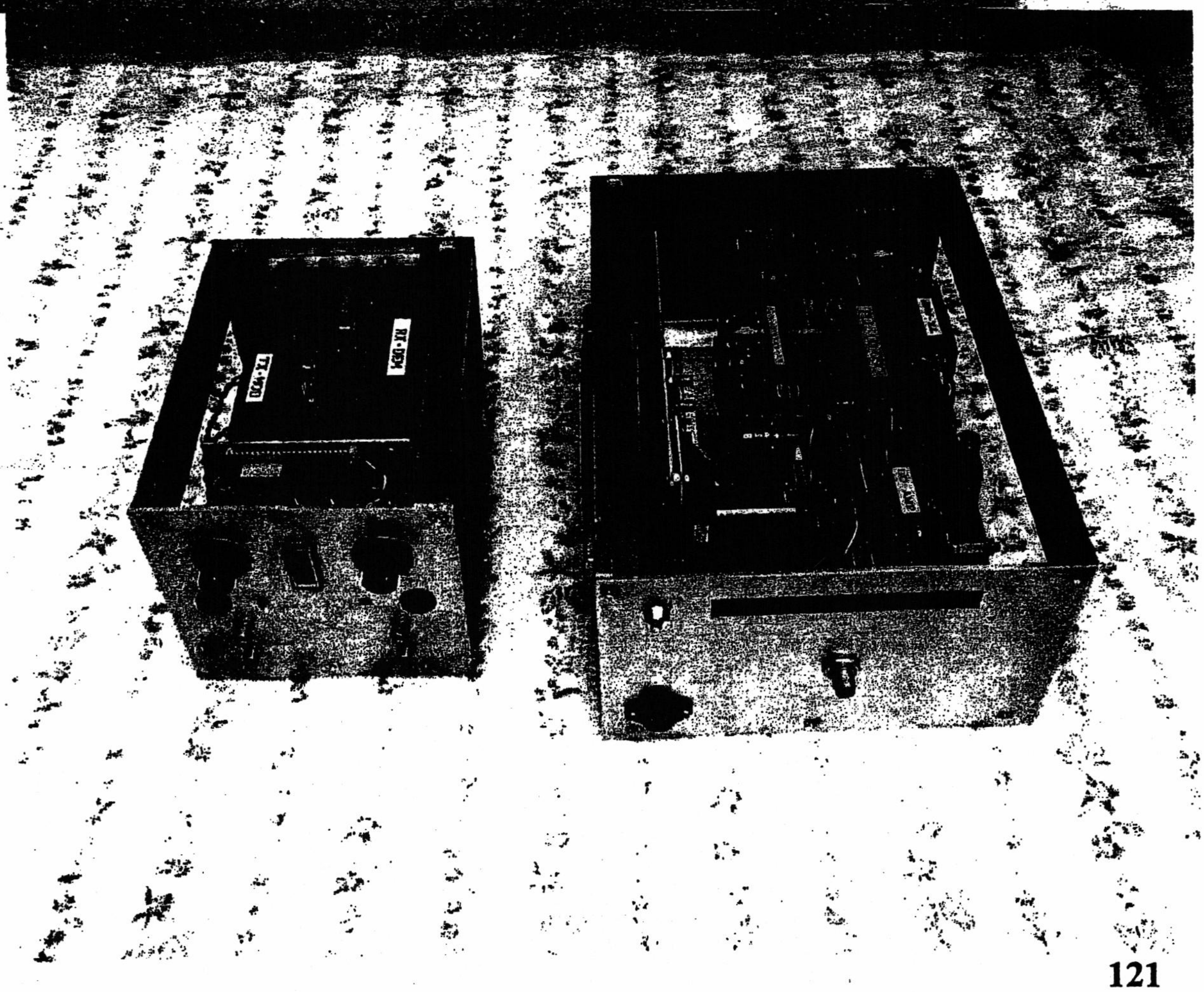


上
47G→1200M
RX コンバーター
LO 24G GUNN

下
75G→1200M
RX コンバーター
LO 38G GUNN

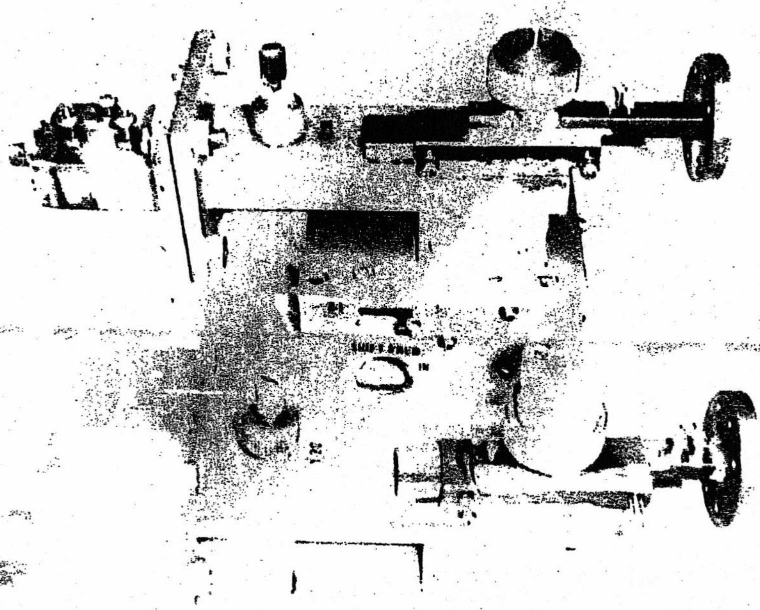


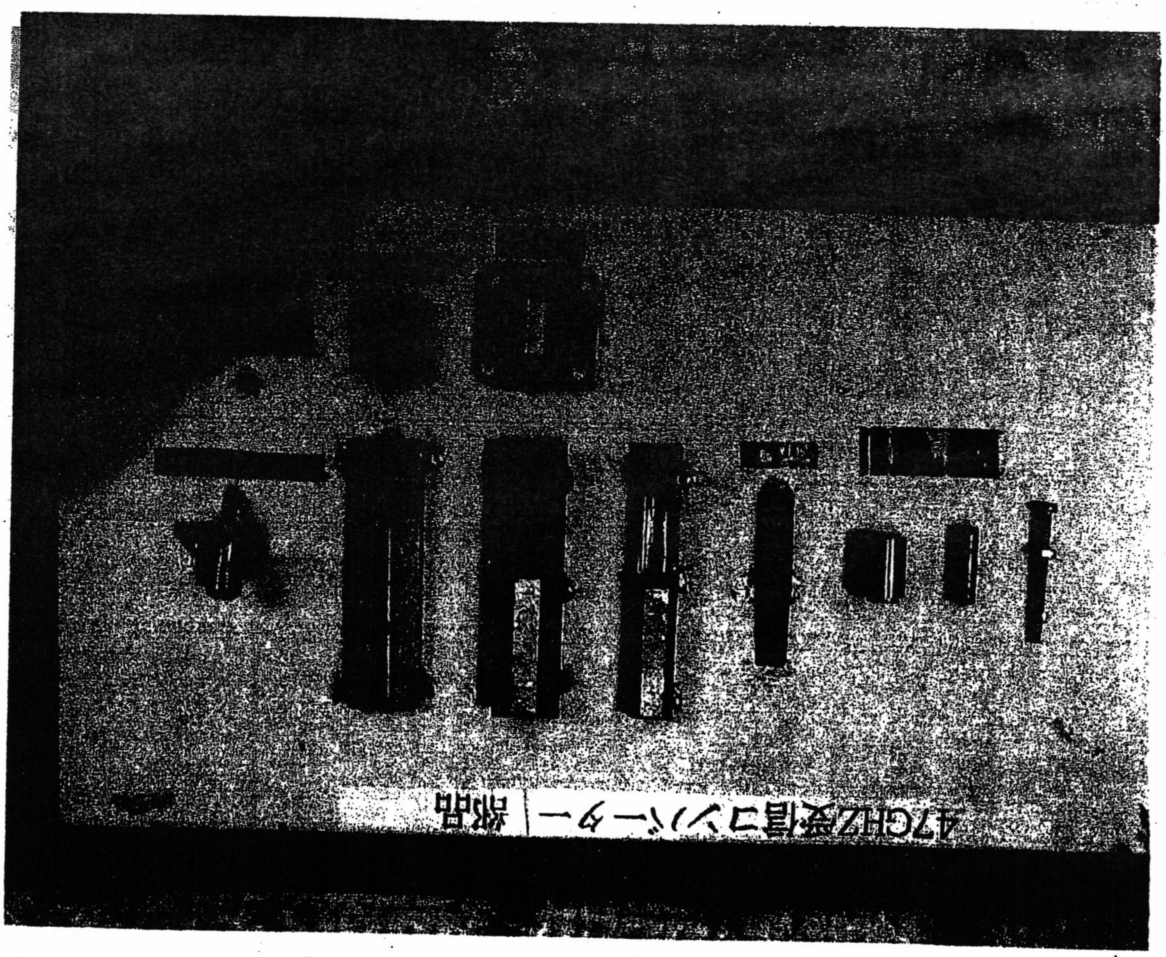
左
24G ATV トランシーバー

右
7G トランスバーター

121

写真2





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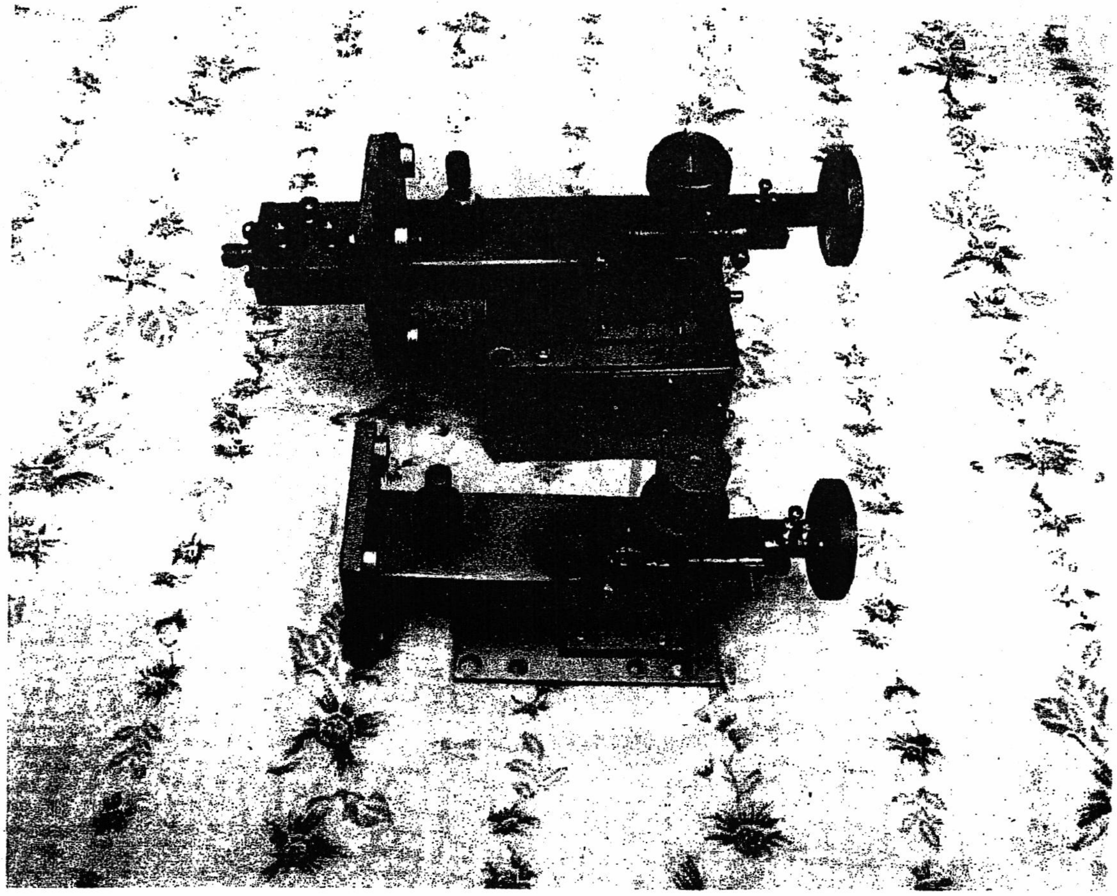

197

123