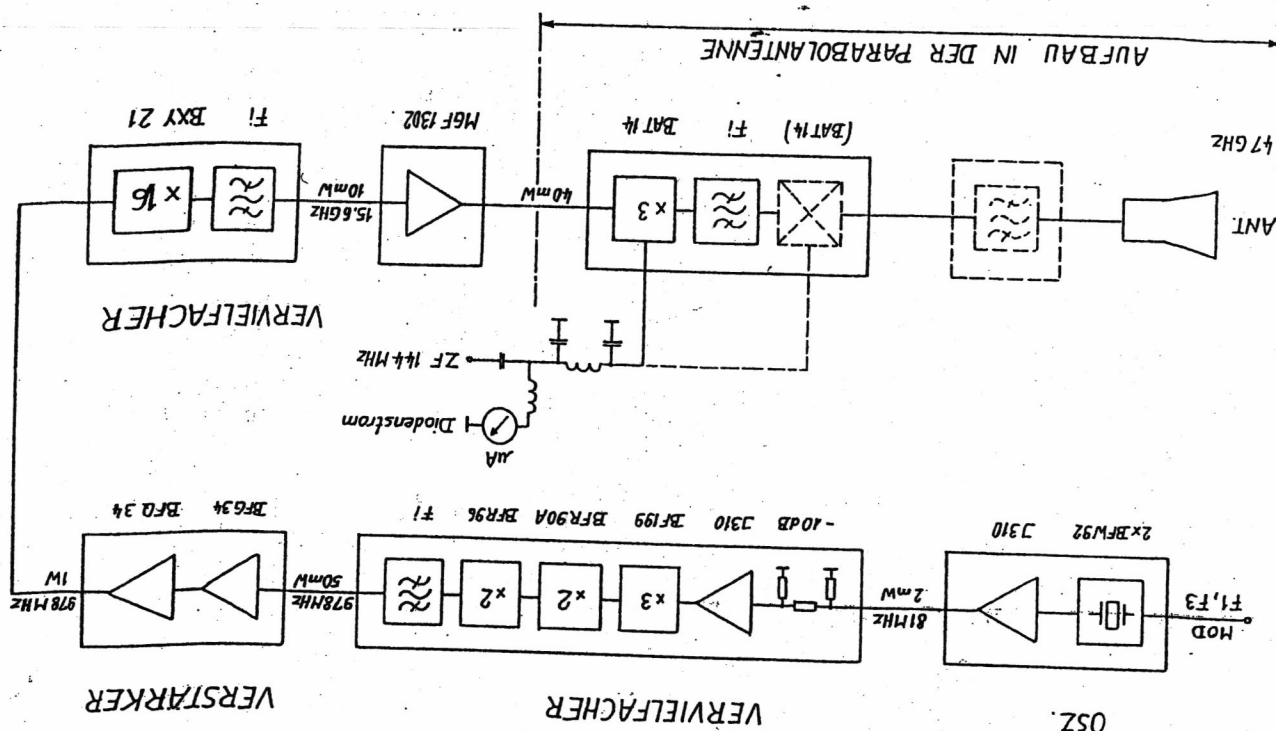


BILD 2 (FIGURE 2): Blockschalbild/Block Diagram



47 GHz Station

Peter Rimi, OE9PMJ

Kurzbeschreibung:

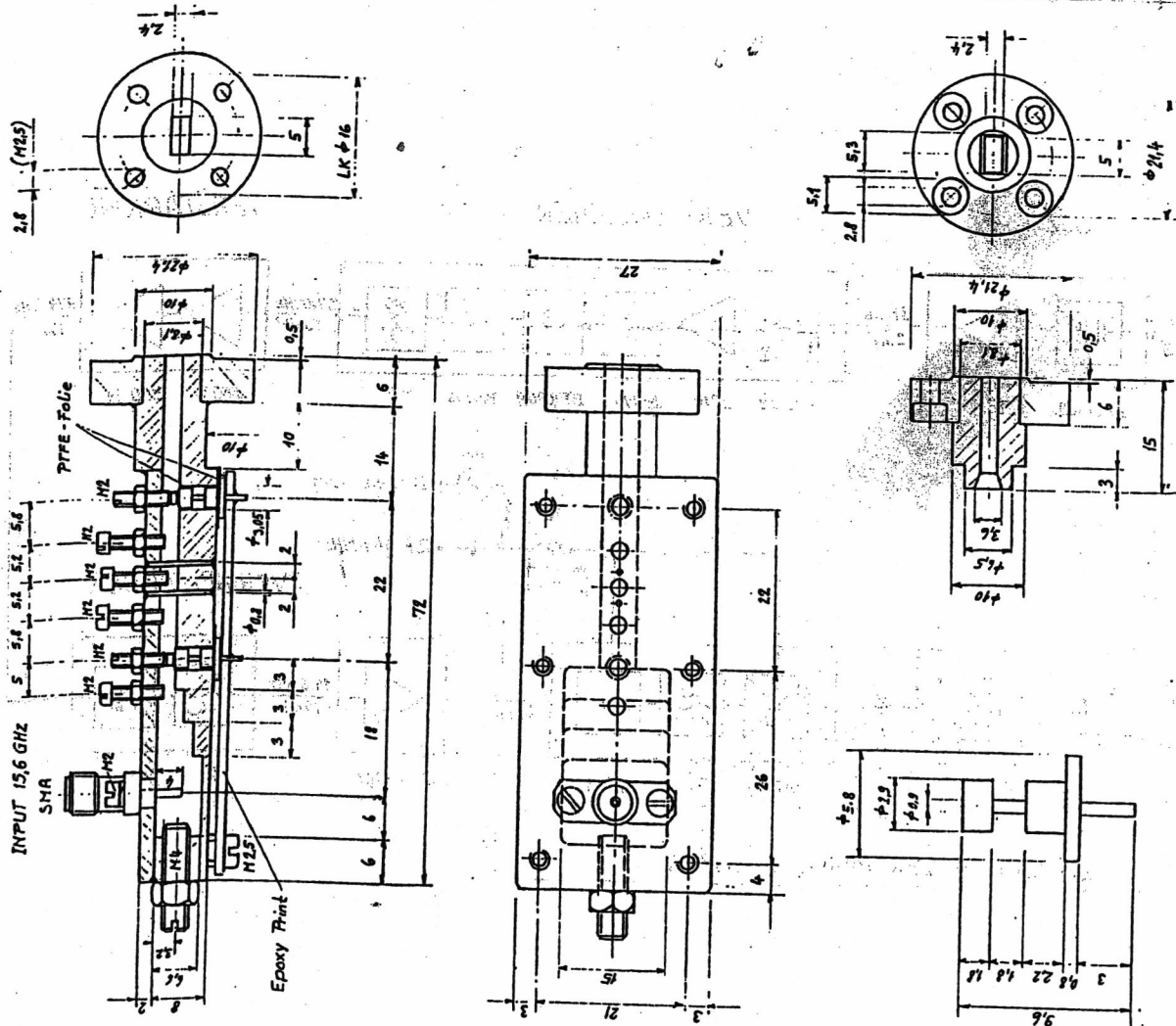
Ein quartzstabiles Signal (Bild 2) von etwa 20...30 mW auf 15,6 GHz treibt einen Dioden-Verdreifacher mit nachfolgendem Filter für 47 GHz. Diese Verdreifacherstufe kann gleichzeitig als TX-RX-Mischer dienen. Im Empfangsfall sollte dann die Steuerleistung auf 15,6 GHz auf 2...3 mW reduziert werden, um die beste Empfindlichkeit zu erreichen.

Versetzt man die Frequenz der Gegenstation (47 GHz) um die ZF, z.B. 144 MHz, und moduliert die Oszillatoren (F3), dann ist Gegensprechen im Schmalbandbetrieb möglich. Bei Verwendung einer BAT14 im Mischer-Verdreifacher werden die Ausgangsleistungen von etwa 10...100 uW erreicht. Damit lassen sich Entfernungen von ca. 20...30 km überbrücken, wenn Antennen von mindestens 40 dBi



Figure 1/Bild 1: Mixer-Multiplier/Hybrid-Horn

FIGURE 3 (BILD 3): Mechanik/Construction



(35 cm Parabol) eingesetzt werden und freie Sicht besteht.

Wird als Verdreifacher eine geeignete (auch teure) Varaktor-Diode eingesetzt, dann läßt sich das 47 GHz Signal in den mW-Bereich bringen und eine nachfolgende Mischdiode ansteuern. Diese Anordnung kann als "Durchblasemischer" oder auch als RX-TX-Mischer mit entsprechenden Filtern betrieben werden.

Der Verdreifacher-Mischer ist in Hohlleitertechnik aus Messing hergestellt und bedarf hohen mechanischen Aufwandes (Bild 3) bei der Anfertigung. Die 8 mm Grundplatte wird zuerst gefräst, dann die 2 mm-Deckplatte aufgeschraubt, die Bohrungen eingebracht, demontiert, entgratet, wiederum verschraubt und weich verlötet. Dann wird der zylindrische Teil angedreht, der vorgedrehte Flansch aufgesetzt, verlötet und plangedreht. In gleicher Weise wird bei der Herstellung des Pyramidhorns vorgegangen.

Als Antennen werden Parabolspiegel mit 35 cm (F/D = 0,4) Durchmesser verwendet. Da der genaue Brennpunkt nicht bekannt war, mußte die Paraboloidform genau vermessen werden, um die genaue Fokusslänge zu berechnen. Abweichungen von mehr als 0,5 mm verursachen bereits feststellbare Verluste. Das verwendete Pyramidhorn ist für ein F/D von 0,4...0,5 ausgelegt.

Für den Einsatz im 76 GHz Band kann der Verdreifacher verwendet werden und der Hohlleiter mit den Abmessungen 3 x 1,5 mm ausgeführt werden.

OE9PMJ at his station/OE9PMJ an seiner Station

Short Description:

A diode tripler to 47 GHz with a filter at its output is driven by a crystal locked signal on 15.6 GHz with a power of 20...50 mW. This tripler can function as RX/TX-mixer also. For this purpose the 15.6 GHz power has to be reduced to 2...3 mW for best sensitivity.

For full duplex one can detune the frequency of the other station just by the offset of the IF-frequency and modulate the oscillators in F3. If a BAT14 diode is used in the mixer-tripler, output powers of 10...100 uW are possible. If the antennas used have gains of at least 40 dBi (35 cm dish) distances of 10...20 km can successfully be crossed.

If a real-varactor diode (expensive!) is used, a power of some mW's is possible and a mixing diode can be driven by this local oscillator signal. This configuration can be used as feed-through mixer or as RX/TX-mixer.

The tripler/mixer is a complex piece of mechanics (Figure 3) and has been constructed from brass in waveguide design. The second piece is the feedhorn for the dish. Extremely rare if for adjusting the position of the dish.

Improved I.F. matching at 1296MHz for a DB6NT 47GHz Transverter

By Paul Widger G0HNW & Martin Farmer G7MRF

Following early tests on 47GHz, with the matching network (see figure 1) as described in the last issue of the Microwave Newsletter, our "group" in the North West decided that, whilst the circuit did work, it was not very good on receive. This was evident when David G8VZT/P and Martin G7MRF/P, were at the Stiperstones in Shropshire during the 24/47GHz contest. Signals from David, G0NVA/P, at Merryton Low were very strong on the transverter that had been modified as described below but on the transverter with the original matching circuit G0NVA's signal could not be heard!

Paul, G0HNW, did some bench work on the original matching network and found it would not perform to his liking – so out came the knife and Paul's theory about the pad on the IF being too big at 1296MHz was put to the test.

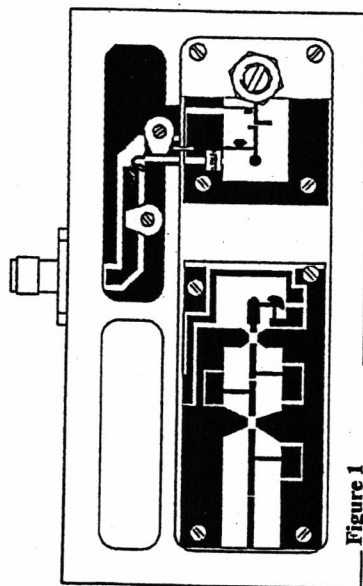
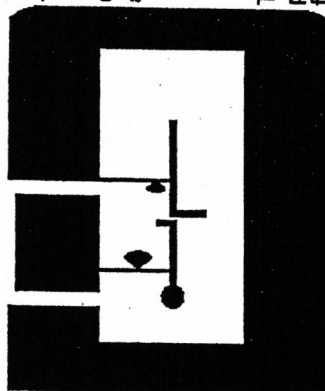
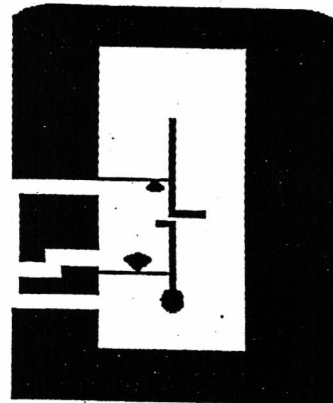


Figure 1

Figure 2



The pad and the coil seem to be resonant at about 139MHz in their original configuration (figure 2) so G0HNW cut the pad on his PCB to suit the direct attachment of 0.085 semi-rigid coax cable.

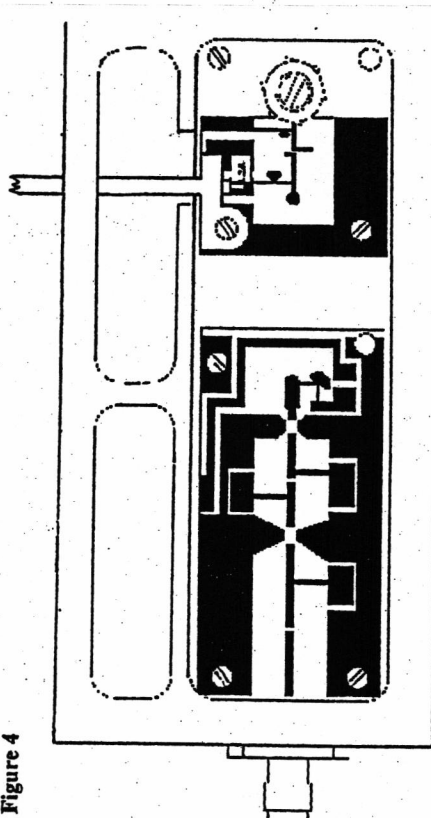


The modified pad is shown in figure 3

Figure 3

As can be seen in figure 4, the semi-rigid cable passes through the well of the transverter case and is held in position by a small, thin piece of brass shim soldered to the outer casing of the cable and then fastened down with the PCB screw. Paul used a small solder tag to achieve the same result.

Figure 4



It was thought that the 15 milliwatts of 1296MHz drive required in the DB6NT design was too high a level for the new layout. After some tests by G0HNW, a value of 1.5milliwatts was arrived at.

G7MRF has also modified his transverter in line with this and also ended up by reducing the drive level, down to 4.5milliwatts in fact. This was achieved by G0NVA/P watching the S-meter on his receiver over the 90km path being worked at the time while a variable attenuator was used on the IF transmit line to determine the best level.

The original matching circuit will be returned to for further investigation in the future when time allows.

Following the modification, G8VZT was able to take signals over a 133K path whereas before, over 90Km, nothing could be heard!

Editor's comment.

Once again, our thanks to Martin and the 47GHz operators mentioned above for this useful information. That elusive 150kmk is not far away!

LOSSY CONNECTORS ...BEWARE!

When I was testing my 6cm transverter with a newly acquired RF Power Meter, I couldn't get more than about 30mW. I was expecting 200mW. I discovered that an N to N male adapter which I bought recently was attenuating the power. Replacing it with one I had had for years, resulted in very little loss.

So beware of some of the cheaper N type connectors and adapters found at rallies, they may be alright at HF but I will not use them again at UHF/SHF!

73 from Neil G4LDR.



47GHz Transceiver

waves. Let's protect our resources from commercial use.

Drake P3D converters

I have shipped many units to overseas. We still have a lot of stocks. If somebody would like to purchase, please e-mail or contact Toshi. Modification is available on Internet as follows. <http://www.geocities.com/siliconvalley/vista7012/drake.htm>

FLL300

Toshi's group is developing S band 30W solid state HPA which employs FLL300 from Fujitsu. It will be two and three stage HPA available. FLL171-FLL120-FLL300 FLL351-FLL300 x 2 unit, it is not difficult to design specially for you. The biggest problem is to construct a sufficient heatsink and a DC power supply to feed. Drain current for one

device is 6A! Simple narrow laminate track which is not carefully concerned on PTFE board should burn out!

24GHz JE1AAH PCB and NE32984D

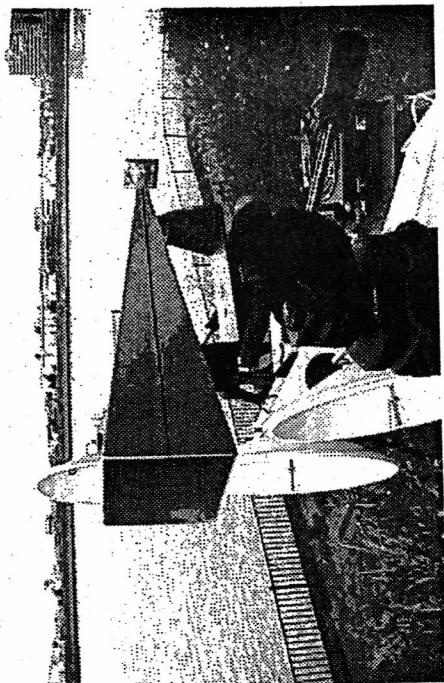
Recently batch process of 24GHz board was finished. Although still there is no plated through holes available, it should help your 24GHz development easier and faster. FHX35LG has demonstrated to produce 50mW which is good substitute to MGF1303. JA0 group has demonstrated 100mW output with two devices in parallel. NE32984D is still the best device for 24GHz LNA which brings NF of 2dB without long time tuning and NF measuring tools. Quantity available.

E-mail address change

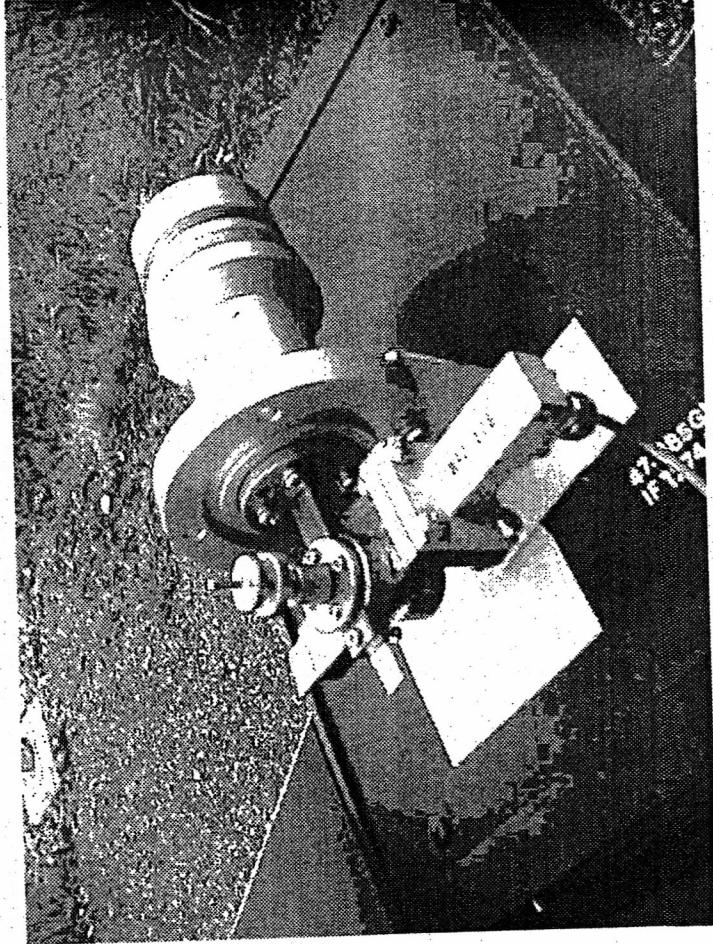
OR domain to NE domain change was done to my e-mail address. New address is "toshi@kw.netlaputa.ne.jp" and "toshi@com-

puter.org" is okay to use.
Fujitsu was changed.

My home address is shown here. 3-28-6 Takaishi, Asao-ku, Kawasaki 215-0003 Japan

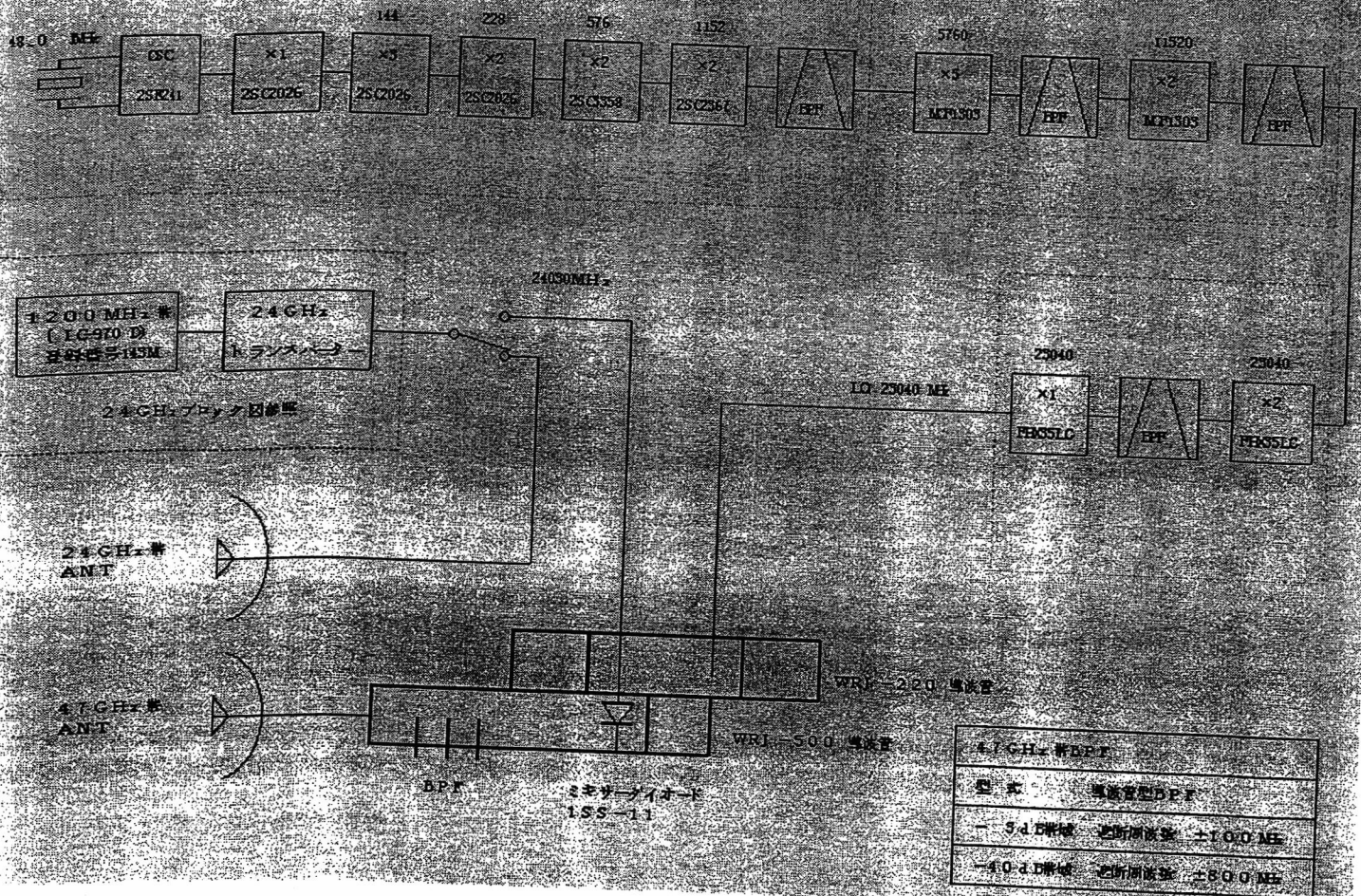


47GHz horn gain 28dB made by JA0RGP



47GHz System

図4-4
47 GHz帯ブロック図



24 + 47 GHz

47GHz Waveguide Switch

(Relais für 47 GHz)

A. Piscitutti, I3OPW & C. Carrer, IW3EHC

Kurzfassung: Ein sehr wichtiges Bauteil einer 47-GHz-Station ist das Send-/Empfangsrelais. Kommerzielle Lösungen sind oft unbezahlbar. Die vorgestellte Eigenbau-Lösung bietet ausgezeichnete RF-Eigenschaften mit geringem Geld- und Arbeitsaufwand.

Abstract: An important module in a 47GHz transverter is the T/R switch. Commercial waveguide switches are quite expensive. A homebrew solution provides low cost and moderate work needed.

Einführung

Der Entwurf entstand aus einer Idee von Gianfranco Sinigaglia (I4BBE) während des 'Congressino Microonde' 1989 in Bologna. Das gleiche Konzept wurde bereits mit vollem Erfolg für ein 10-GHz-Relais verwendet (1).

Introduction

The design stems from an idea of Gianfranco Sinigaglia (I4BBE) in 1989. The design has been realized as a waveguide switch on 10GHz [1].

Mechanik

Drei 35-mm Abschnitte eines WR-19 Hohlleiters (1, 2, 3) werden auf einer Seite mit Flanschen (4, 5, 6), und auf der anderen Seite mit beweglichen Kurzschlüssen (7, 8, 9) versehen. Danach werden die drei Stücke gestapelt (der mittlere in senkrechter Lage zu den beiden anderen) und zusammengelötet. Der

entstandene Block wird mit einem 1 mm Bohrer durchbohrt (10).

Der Elektromagnet (11, RS 250-0748) wird mittels einer Schraube (12) durch das ösenförmige Loch (13) eines Aufgewinkels befestigt. Der Winkel (14) ist aus einem 1mm dicken Messing-Streifen von 15 mm Breite, mit zwei Seiten von 15 bzw. 39 mm geschnitten. Das Loch ermöglicht die Justierung der Magnetspule.

Die Probe (15) wird aus einem Stück semirigid-cable (Typ UT0047) von 20 mm Länge gewonnen. Der Kupfermantel und der Innenleiter werden entfernt, und ein 4 mm langes Stück des Innenleiters (16) wird nochmals in den Teflon eingesteckt.

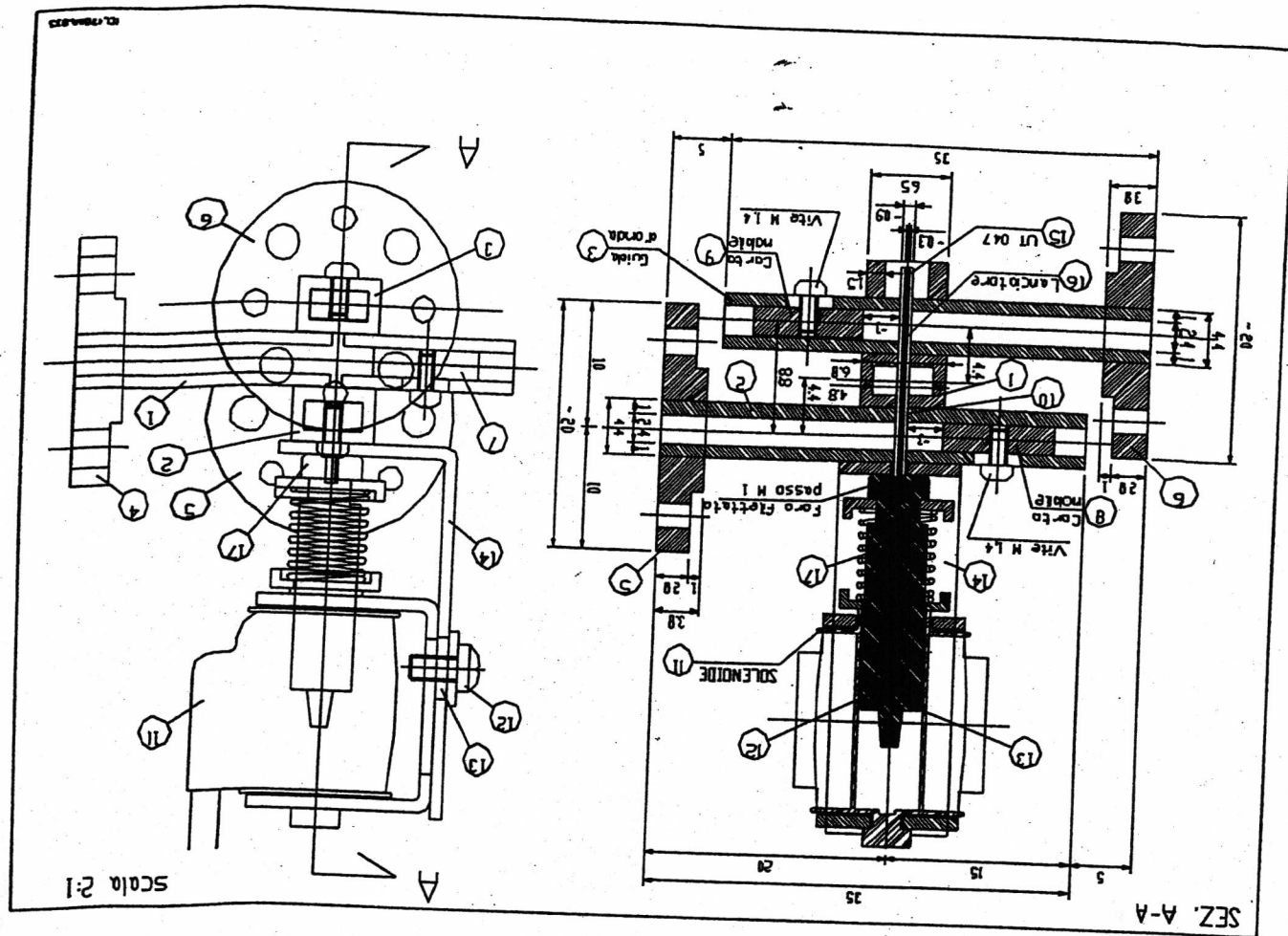
Die Probe wird in dem beweglichen Magnetkern (17) eingeschraubt. In den Kern wird zuerst axial ein Loch mit 0,8 mm gebohrt; anschließend wird mit einem M1 Gewindebohrer ein Gewinde in den Kern geschnitten. Das Gewinde ermöglicht die Feinjustierung der Probe.

Um die Probe in Ruhestellung zu schützen wird ein kurzes Stück Messingrohr (18) zuge-
lötet.

Construction

Three 35mm long pieces of WR-19 waveguide are prepared with a flange on one side (4, 5, 6) and with adjustable shorts on the other side (7, 8, 9). The three pieces are soldered as a sandwich with the middle part in 90 degrees

Fig. 1: Mechanical Drawing



4. Meßergebnisse

Bei allen nach diesem Projekt realisierten Prototypen konnten folgende Ergebnisse erreicht werden:

Einfügungsämpfung : besser als 0,5 dB
Isolation : besser als unsere Meßgrenze von ca. 45 dB.

Measurements

The following results can be obtained:

Insertion loss: < 0.5dB
Isolation: > 45dB

Neue Entwicklungen

Auch eine 24-GHz Version des Relais ist als Prototyp gebaut worden. Es konnten auch hier hervorragende Messergebnisse erzielt werden.

Zeichenerklärung/Legend:

- 1, 2, 3 Hohlleiter/Waveguides
- 4, 5, 6 Flansche/Flanges
- 7, 8, 9 Kurzschlüsse/Shorts
- 10 1 mm Bohrung/Thread
- 11 Elektromagnet/Solenoid
- 12 Schraube/Screw
- 13 Loch/Hole
- 14 Auflegewinkel/Mounting Flange
- 15 Probe (Teflonrohr UT0047)
- 16 Probe (Innenleiter UT0047)
- 17 Magnetkern/Actuator

New Developments

A similar version of the waveguide switch has been constructed for 24GHz.

Literaturhinweis:

1. A. Piscitutti, D. Fachin : "High performance RF-switch for 10 GHz", DUBUS Technik III. Armando Piscitutti, I3OPW, Viale della Resistenza 44B, I-30020 Quarto d'Altino
- Costante Carrer, IW3EHQ, Via don Danesin 1, I-31058 Susegana

orientation. The resulting block has to be drilled with a 1mm hole (10).

The magnet (11, RS 250-0748) is mounted with a screw (12) to a mounting flange. This flange is cut from a 1mm brass plate. The dimensions are 15mm wide and 15/39 mm to the both sides.

The probe 815) is made from a 20mm long piece of UT-047 (Semirigid). The sleeve and the center conductor are removed. A 4mm long piece of the center conductor is reinserted into the 20mm teflon sleeve. This assembly serves as a movable probe, which is moved by the solenoid between the three waveguide pieces.

To achieve this the probe is mounted into the movable actuator of the solenoid. AM1 thread is cut into the actuator. This thread serves for mounting the probe and allows for small adjustments.

Abstimmung

Zuerst wird die Lage des Magnetkernes und die Lage der Probe so eingestellt, dass in der Ruhelage der Innenleiter der Probe symmetrisch 1,2 mm in die beiden betroffenen Hohlleiter eindringt. Anschließend wird der Hub so eingestellt, dass die gleiche Eindringtiefe auch in der Tx-Stellung (bei aktiviertem Magnet) erreicht wird.

Durch die Verstellung der beweglichen Kurzschlüsse wird zum Schluß die niedrigste Einfügungsämpfung eingestellt. Die Einstellung sollte für die TX- und die RX-Seite in beiden Richtungen (d.h. insgesamt vier Meßvorgänge) durchgeführt werden.

Alignment

With deactivated solenoid the probe and/or the actuator is adjusted in such a way that the probe inserts symmetrically in the two waveguides (about 1.2mm on both sides). In a second step the travel of the actuator is adjusted for the same condition on the active position of the actuator.

By adjusting the movable shorts the insertion loss for the TX and RX-path is minimised. The measurements are done in both directions, so that totally four measurements are needed.

Microwave Products

Editor: Reiner Bertelsmeier, DU9BV

FLL1500IU-2A L-Band High Power GaAs FET

FEATURES

- Push-Pull Configuration
- High Power Output: 150W (Typ.)
- High PAE: 45%
- Broad Frequency Range: 2100 to 2200 MHz
- Suitable for class AB operation.

DESCRIPTION

The FLL1500IU-2A is a 150 Watt GaAs FET that employs a push-pull design that offers ease of matching, greater consistency and a broader bandwidth for high power L-band amplifiers. This product is targeted to reduce the size and complexity of highly linear, high power base station transmitting amplifiers.

This new product is uniquely suited for use in W-CDMA base station amplifiers as it offers high gain, long term reliability and ease of use.

APPLICATIONS

- Solid State Base Station Power Amplifier.
- W-CDMA Communication Systems.

ABSOLUTE MAXIMUM RATINGS (Ambient Temperature T_a=25°C)

Item	Symbol	Condition	Rating	Unit
Drain-Source Voltage	V _{DS}		15	V
Gate-Source Voltage	V _{GS}		-5	V
Total Power Dissipation	P _T	T _a = 25°C	187.5	W
Storage Temperature	T _{stg}		-65 to +175	°C
Channel Temperature	T _{ch}		+175	°C

Fujitsu recommends the following conditions for the reliable operation of GaAs FETs:

1. The maximum power dissipation (P_T) should not exceed 175 W.
2. This forward bias gate current should not exceed 25 mA and 80 mA respectively with gate resistance of 10Ω.
3. The operating channel temperature (T_{ch}) should not exceed 140°C.

ELECTRICAL CHARACTERISTICS (Ambient Temperature T_a=25°C)

Item	Symbol	Conditions	Limits		Unit
			Min.	Typ. Max.	
Drain Current	I _{DS}	V _{DS} = 5V, V _{GS} = 0V	-	72	A
Transconductance	g _m	V _{DS} = 5V, I _{DS} = 32A	-	24	S
Pinch-Off Voltage	V _p	V _{DS} = 5V, I _{DS} = 4.32A	-1.0	-2.0	-3.5 V
Gate-Source Breakdown Voltage	V _{GS}	I _{DS} = -4.32mA	-5	-	V
Output Power	P _{out}	V _{DS} = 12V f = 2.2 GHz	50.8	51.8	dBm
Linear Gain	GL	I _{DS} = 6.0A Pin = 42.0dBm	10.0	11.0	dB
Drain Current	I _{DS}		-	25	30 A
Power-Added Efficiency	η _{add}		-	45	%
Thermal Resistance	R _{th}	Channel to Case	-	0.6	0.8 °C/W

CASE STYLE: IU

High Performance 47 GHz Transverter mit 50 mW Ausgangsleistung

von E. Zimmermann HB9 MIN CH-4585 Biezwil

Nach der Freude am gelungenen 86 km QSO auf 47 GHz (Gunnosc. und Breitband FM) setze ich ein Jahr später folgende Nachricht in grosses Erstaunen: WA 3 RMX hat mit seinem 47 GHz SSB Transverter und einem 5 mW TWT Verstärker, 105 km überbrückt: Weltrekord! Mein Ziel war es nun, eine DX-fähige Station mit besseren Daten zu entwickeln. Das dies gelungen ist, zeigen die Verbindungen über mehr als 100 km Distanz.

In diesem Vortrag möchte ich von der Arbeit, den Erfahrungen sowie den Feldversuchen berichten. Lichtbilder und eine Demonstration des neuen Modulationsverfahrens runden den Vortrag ab. Detailveröffentlichungen folgen aus Zeitgründen später in der DUBUS.

Techn. Anforderungen, Schaltungskonzept

In diesem Abschnitt werden die geforderten elektr. Daten, deren Konsequenzen sowie die dadurch notwendig gewordene Entwicklung eines neuen SSB Modulationsverfahrens dargestellt. Fast alle Daten und Fakten mussten mit Versuchsaufbauten verifiziert werden.

- Rauschzahl = 10 dB
 - Keine Subharmonische Mischer
 - MMIC-Verstärker mit 2 dB NF gibt es, aber nicht für Amateure
 - Versuche mit PM-HEMT Verstärker.
 - NF $\leq$ 10 dB erreicht man mit Rat-race-Mischer (GaAs Dioden)
 - daraus ergibt sich: min 7 dBm LO Leistung auf 46 GHz.
- LO Leistung > 7 dBm
 - 23-46 GHz Diodenverdoppler haben 12 dB Verlust. Eigenbau?
 - ein 23 GHz 100 mW Verstärker ist dazu erforderlich.
 - Entwicklung eines 23-46 GHz GaAs Fet-Verdopplers mit 7 dB Conversion Loss.

- 2 -

- Sendeleistung > 10 dBm

- Verstärker MMIC gibt es, z.B. 35 GHz: Po 1W 10 dB Gain, 60 GHz: Po 250 mW 13 dB Gain, wer schenkt mir welche?
- mit LowNoise PM-HEMT ist nur ca. 1 mW möglich.
- Injection Locking Amplifier: 100 mW möglich. Nicht SSB tauglich!
- Dioden, Varaktoren oder GaAs Fet-Verdoppler Po 7...17 dBm. Nicht SSB tauglich!
- Man erinnere sich: Hüllkurvenelimination und Restauration von DL3VWR, PLL-SSB von PAØ xxx (Dubus).

- Hüllkurveneliminations- und Restaurationsverfahren und PLL-SSB sind nicht geeignet

- schlechte Modulationsqualität
- Lockout-Effekte beim μ W PLL
- Amplituden-Restauration ist bei Verdopplern und Vervielfachern nicht möglich

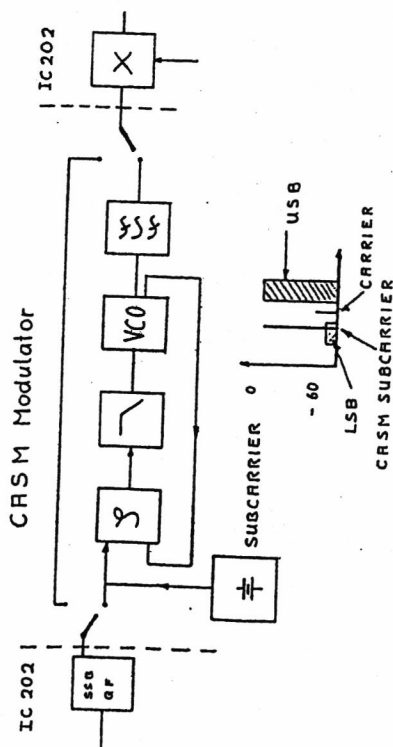
daraus folgt, dass ein neues SSB Modulationsverfahren gesucht werden muss, um das Ziel von > 10 dBm Ausgangsleistung zu erreichen.

CASM Constant Amplitude Single Side Band Modulation

Mit erheblichem Aufwand wurde in monatelanger Arbeit ein neues Modulationsverfahren entwickelt und erprobt, bei welchem die Nachteile von PLL-SSB nicht vorhanden sind.

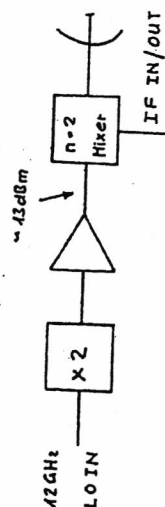
- Vorteile:**
- sehr gute Sprachqualität, von SSB kaum zu unterscheiden.
 - hoher Modulationsgrad, Vorteil bei schwachen Signalen!
 - Empfangsseitig kompatibel zu SSB
 - keine Lockout-Effekte bei μ W PLL's
 - kann in Klasse C verstärkt werden.
 - kann in Injektion-Locking-Amplifier verstärkt werden.
 - kann vervielfacht werden

Das USB-Signal gelangt vom Quarzfilter, pegelrichtig zusammen mit dem Subcarrier in den PLL-Modulator. Am Ausgang steht dadurch ein Amplitudenkonstantes SSB-Signal zur Verfügung. Das konventionell weiterverarbeitet werden kann. Der CASM-Modulator wurde erfolgreich in ein IC202 und ein FT 290 eingebaut.



47 GHz Transverter der 1. Generation

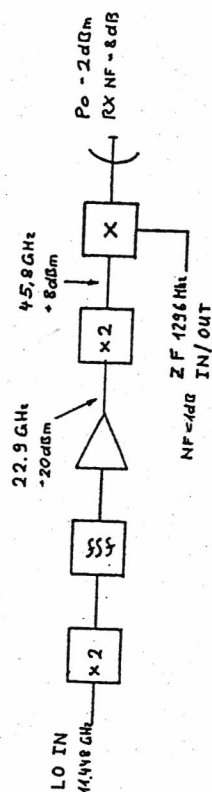
Der Oberwellenmischer hat den Vorteil, dass er auf der halben LO-Frequenz angesteuert werden kann. Selbst optimierte Schaltungen haben den Nachteil von hoher Rauschzahl und kleinen Ausgangsleistung.



1. Generation 47 GHz Transverter
by DB 6 NT, HBG MIN
Pout 0,4 mW RX NF ~ 20 dB

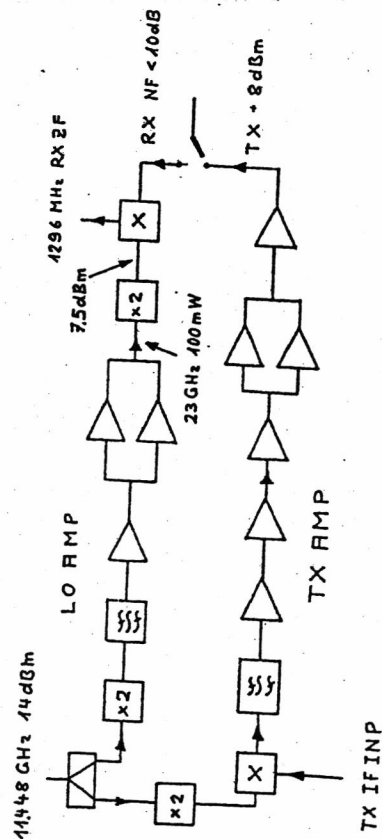
47 GHz Transverter der 2. Generation

Auch hier ist der Mischer, die Baugruppe, die Rauschzahl und Sendeleistung bestimmt. Gegenüber den Oberwellenmischer hat ein Rat-race-Mischer mit GaAs Beam-leadioden einen wesentlich kleineren Conversion-Loss, d.h. kleinere Rauschzahl und höhere Sendeleistung. Diese Vorteile müssen aber mit höherem Aufwand auf der LO-Seite erkauft werden.



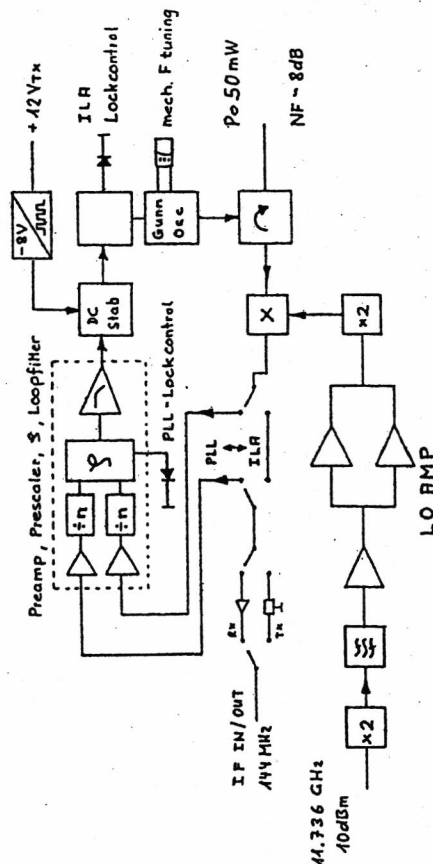
47 GHz GaAs Fet-Transverter

Das zweite Gerät des Verfassers zeichnet sich aus, durch kleine Rauschzahl und 9 dBm Ausgangsleistung. Der Sendezweig ist vollumfänglich mit GaAsFet bestückt. Aus dem Schalbild ist der massive Aufwand deutlich ersichtlich, mit welchem die Sendeleistung gegenüber der 1. Generation um 20 dB erhöht werden konnte. Ein Wort zum Quarzoszillator: Die Oszillatorschaltung ist zweistufig und besteht aus zwei P8000 JFet's. Gefolgt von einem Schotkydiodenbegrenzer. Ein hoch isolierender Ausgangsverstärker verhindert Rückwirkungen. Die gesamte Schaltung inkl. Spannungsstabilisator wird durch einen Temperaturregler auf konstante 45° gehalten. Messungen ergaben eine Frequenzänderung von max. 500 Hz auf 47 GHz bei einer Temperaturänderung von + 20°C auf -30°C.



Transverter mit 50 mW Ausgangsleistung

Auch hier besteht das RX Frontend aus einem GaAs Beamlead-Dioden Rat-race Mischer. Mit einem 50 mW Gunnoszillator im Sender konnte die Ausgangsleistung weiter erhöht werden. Beim Senden kann zwischen zwei Betriebsarten umgeschaltet werden. Bei der ersten Arbeitet der Gunnoszillator als Injection-Locking-Amplifier (~20 dB Gain bei 300 MHz Bandbreite), mit welchem das vom Mischer kommende Signal verstärkt wird. Bei der zweiten Betriebsart, arbeitet er als PLL gelockten Gunnoszillator. Hier wird der RX-Mischer als Down-Converter für den PLL verwendet. Danach folgen Verstärker, Frequenzteiler, Phasenvergleicher, Loopfilter sowie ein schneller, moduliertbarer, rauscharmer Spannungsregler. Die beiden Betriebsarten funktionieren nur mit ZF-seitiger CASM Modulation. Locking-Control-Schaltungen überwachen das richtige funktionieren des IIA bzw. PLL in harten Feldeinsatz ohne dass ein Spektrumanalyser mitgeschleppt werden muss.



447GHz SSB Transverter with 50mW Output Power HB9MIN

Zusammenfassung, Danksagung

Es wurde gezeigt, wie mit amateurmäßigen Mitteln ein High-Performance-Transverter gebaut werden kann. Ueber DX-Versuche wird anlässlich der UKW-Tagung in Weinhelm berichtet.

An dieser Stelle möchte ich all denen die mit Diskussionen, Ideen und Komponenten zu gelingen beigetragen haben, herzlich danken.

Besonderen Dank gebühren HB9BAT Emil Zellweger, für die Einführung in die PLL-Technik sowie HB9AGE, Walter Hanselmann und Klaus Solbach DK3BA.

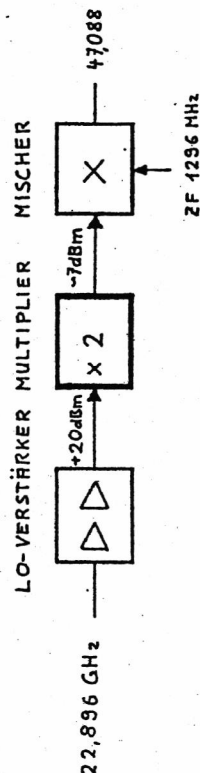
23-46 GHz Multiplier

HB9MIN E. Zimmermann

Hauptstrasse 131, CH-4585 Biezwil

47 GHz Gegenakt Mischer mit GaAs Dioden müssen für kleinen Mischverlust mit 5...10 dBm LO-Leistung angesteuert werden. Dies scheint wenig zu sein, in Tat und Wahrheit sind 10mW auf dieser Frequenz schon eine beträchtliche Leistung, die mit Aufwand verbunden ist.

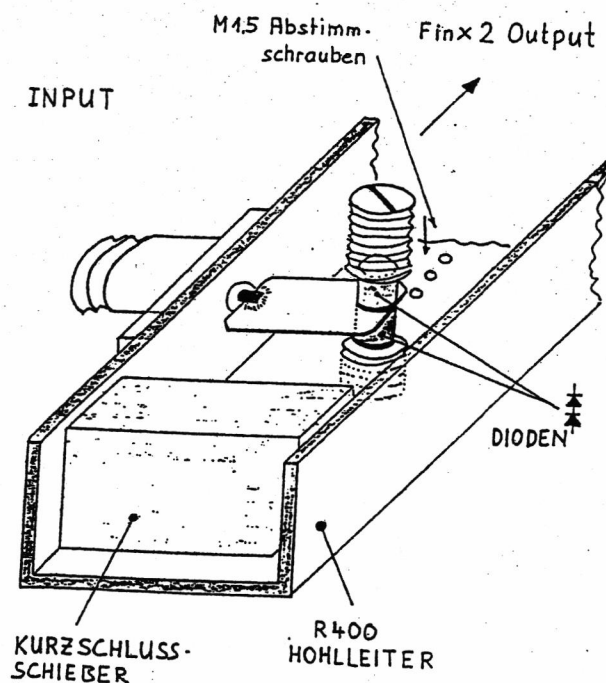
Bisher veröffentlichte Konzepte wie DB 6 NT steuerten ihre Oberwellenmischer mit 10 mW auf 223 GHz an. Einzig WA3RMX hatte in seiner Weltrekordstation (106 km) 1 mW auf 46 GHz zur Verfügung um den Mischer anzusteuern. Ein GaAs FET- Verdoppler mit hohem Wirkungsgrad habe ich mit Erfolg aufgebaut und in Betrieb. Der Aufwand ist jedoch erheblich, nebst den teuren FET's. In diesem Beitrag wird gezeigt, wie durch einen Dioden-Verdoppler 8 dBm LO-Leistung erzeugt werden kann. In der 47 GHz Station des Verfassers funktioniert ein solcher Verdoppler, welcher mit einen 23 GHz 100 mW Verstärker angesteuert wird, seit Jahren unter extremen Bedingungen zuverlässig.



47 GHz Transverter

Schaltungsbeschreibung

Dieser Verdoppler arbeitet mit zwei in Serie geschalteten Mischerdioden im R 400 Hohlleiter. Das Eingangssignal (23 GHz/100 mW) wird auf der Hohlleiter-Schmalseite über einer SMA Buchse und einer 50 Ω Leitung aus Cu-Folie auf den Dioden Mittelpunkt geführt. Die verdoppelte Frequenz wird über den Hohlleiter ausgekoppelt. Da Fin unterhalb der Hohlleiter-Cut-off-Frequenz liegt, ist Fin am Ausgang nicht mehr vorhanden. Ein Kurzschlusschieber und drei M 1,5 Abstimm-schrauben erlauben ein optimaler Abgleich. Als Dioden eignen sich BAT 14 im Micropill-Gehäuse, welche vorsichtig mit Niedertemperaturlot auf M 2,5 Schrauben aufgelötet werden. Ein symmetrischer sowie ein mechanisch sauberer Aufbau ist die Voraussetzung für einen guten Wirkungsgrad. Da die Eingangsimpedanz nicht genau 50 Ω ist muss die Anpassung am Treiberverstärker Ausgang korrigiert werden. Optimal ist den Verstärker und Verdoppler in einem Modul zu vereinigen.



Messwerte

Eingangsfrequenz :	23,5 GHz	17...20 dBm
Ausgangsfrequenz :	47 GHz	5...8 dBm
Conversion Loss :	> 12 dB	

47GHz NARROWBAND

EXPERIENCES OF ONE GROUP

By Martin Farmer G7MRF and David Woodward G0IVA

INTRODUCTION

After some discussion, Tony, G4CBW and Martin, G7MRF, decided that we would become operational on 47GHz. David, G0IVA, was also encouraged (!) to build for the band. Both G4CBW and G7MRF decided to use 1296 MHz as the IF frequency. This not only allowed the use of the multimode kit, which contained 1296 MHz TV gear, but also the local oscillator frequency was the same as the existing 24GHz setup. G0IVA decided to stick with the 2 metre IF to make the gear more portable for hill-topping or roving.

The HSC-9251 diodes were sourced from a supplier in Italy (see end for details), the postal delivery on these being about one week. The DB6NT pcbs were obtained via either the Microwave Committee Components Service or DB6NT. The fixing of the DB6NT boards into the milled enclosure was done using M2 screws and silver epoxy. G7MRF modified the design of the transverter's milled aluminium enclosure to allow the use of 1296 MHz IF. G0IVA used the DB6NT enclosure drawings without modification, except for the use of BA threads instead of metric throughout - due to not having any metric taps!

LO AND 12/24GHz MULTIPLIER

G7MRF and G4CBW used the already well known DDK004/WVDG009 combination for the 11.448 GHz local oscillator. G0IVA decided to try the DB6NT 12 GHz local oscillator (for 11.736 GHz) primarily since this was in just one box and would keep the size of the whole transverter down. The DB6NT unit tuned up satisfactorily giving about 40 mW output. All the oscillators were run for several weeks prior to finishing the transverters to age the crystals before setting final frequency, etc.

The DB6NT 12/24 doubler was built using NE32584C devices not the MGF1302 as stated in the DUBUS construction article. The deviation from the specified devices was based on previous experience with a 12/24 doubler that was built for use in the forthcoming 24GHz beacon GB3NUL. This initially used MGF1302 devices and did not achieve the stated output power until the MGF1302s were changed for MGF1903B, the output power then achieved the required level. It was therefore decided to try NE32584Cs in the multiplier for the 47 GHz transverters.

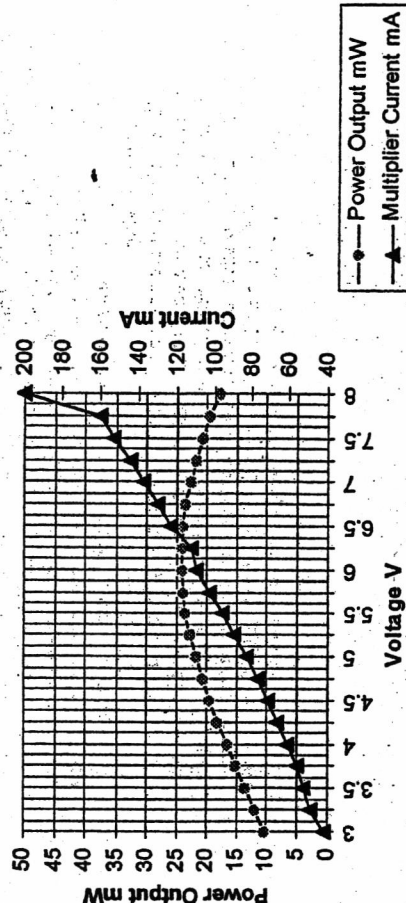
To allow the tuning and power measurement of the doubler, a block of copper 6mm thick (G0IVA used some much thinner brass sheet) was made up to fit in the space and use the fixing holes of the 47 GHz mixer pcb. This block had a small section of RG405 semi-rigid passing through and soldered to the top side of the block with a SMA connector on the other end. The centre conductor and dielectric were trimmed to project 2.5mm into the high pass filter section. This made quite a rigid test point. With approx. 40mW LO injection the multiplier was tuned. All three units gave about 20 mW (at 23.472 GHz for G0IVA and 22.896 GHz for G7MRF /G4CBW).

This output was achieved with the 7808 (8V) voltage regulator as in DB6NT's original design (when using MGF1302s). Measurement of the voltages/currents with NE32584Cs fitted showed that these were all a bit high, exceeding the device ratings. With no changes to the multiplier resistor values (or tuning shims), the voltage to the multiplier board was reduced to see the effect on the 23 GHz power output. The max power output of 24 mW was reached with 6V applied but still the voltages/currents were a bit high. In the interests of preserving the devices, the 5V was chosen. This voltage still gave about 22 mW output on G0IVA's unit (similar on the others). This was considered adequate for the 47 GHz transverter. Subsequently the transverter voltage regulator was changed to a

7805 (5V) type. see figure 1 showing power output (and multiplier current drawn) versus voltage for the 12/24 GHz multiplier.

Figure 1

Power Output (and Current) from DB6NT
12/24 GHz Multiplier with NE32584C devices.



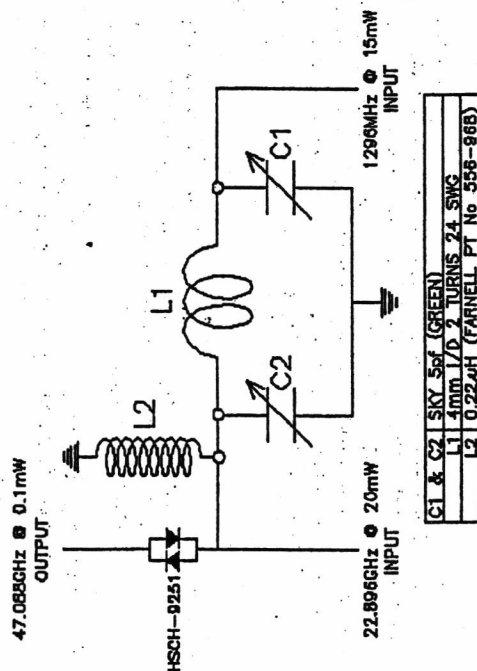
IF NOTES

In DB6NT's design of IF board there is provision for a FET switching a resistor in the supply to the multiplier board. This reduces power output of the LO multiplier when in receive and with full voltage on transmit. This allows optimisation for best noise figure on receive and maximum power out on transmit. This has not been fully tried yet as we have no reliable means to check noise figure at 47 GHz! Initial attempts with reduced LO did not show any substantial improvement. In fact the HP data for the single and series pair versions of the mixer diodes shows about 0.5 dB improvement when reduced from 13 dBm to 6 dBm. At present we are using the full LO multiplier output on transmit and receive. Further tests will be carried out with variable LO drive to determine best receive performance.

The 144 MHz IF amplifier device was specified as the HP AT41485 (6 GHz low noise silicon bipolar). However G0IVA had some surplus HP AT42035 (6 GHz medium power silicon bipolar) which are similar (gain/NF), so one of these was used instead with satisfactory results.

A 1296 MHz IF matching circuit, originally used to good effect in G7MRF's and G4CBW's 24GHz systems, was fitted next to the 47 GHz mixer board, see figure 2. This was fed with 10-15mW of RF on transmit, via attenuators, from the 1296 MHz transverter. The large pad on the IF input of the 47GHz board produced no strange effects on the 1296 IF and was left at its original size. In the receive path the matching section feeds into one of Rainer Bertelsmeier's (D9BV) HEMT LNAs as described in DUBUS TECHNIC IV. The output of this LNA then passes to the 1296 MHz transverter.

Figure 2 - 1296 MHz IF Matching Network



FITTING 47 GHz MIXER PCB AND MIXER DIODE, ETC

The doubler pcb presented no problems in securing into the transverter casing but the 47GHz pcb presented a few challenges. Here is the method that G7MRF used to mark and fix the pcb. There are two 1.7mm holes, 4mm from either end of the high pass filter section located on the underside of the transverter case. The filter output hole was drilled with the smallest drill available (0.3mm) and a small pin was pushed through the pcb where the probe locates. This allowed the end of the pin to sit in the small hole, that has been drilled in the casing, thus allowing the pcb to pivot around from side to side. With the pcb held in place by the pin you can hold the transverter case up to a strong light and by looking down the 4mm output hole you should be able to rotate the pcb until it is in the right position and temporary fasten using Sellotape, now all the pcb mounting holes can be positioned and drilled. With the pcb removed the small location hole can now be opened up to the correct size of 1.7mm.

The backside of the board is now covered with silver epoxy and a thin film smeared where the board locates. Using a cotton bud clear the epoxy from the input and output points and position the board into the milled box. As the 47GHz pcb is very thin, a pencil rubber was placed over the board and the lid of the transverter screwed down to flatten the board to the box. With the rubber still in the box, providing backing to the thin board, a cotton bud or other cleaning swab can now be used to remove the excess epoxy from the probe hole and the waveguide output hole. The rubber can now be removed and the epoxy cured.

GOIVA used a similar method, but the 47 GHz mixer pcb was a much tighter fit into the enclosure. The pcb was trimmed by very small amounts until the LO input probe hole and the output to the waveguide aligned with the corresponding holes in the enclosure.

The diode is "micro-sized" and it goes without saying that great care is required in placing and securing it to the pcb, the use of a microscope being essential. The method followed by G7MRF is described here. Lightly scratch the area on the tracks that the diode sits, with the end of a pin. Pick up the smallest amount of Epo-Tek H20E silver loaded epoxy on the end of a pin and put two small

blobs on the track, spreading it around. Pick up the diode by the end of a pin and position over the two blobs of epoxy. Push the centre of the diode body down with the pin and with another pin push one leg of the diode, then the other, into the epoxy. When set, very small deposits of epoxy can be built up on top of the leads to encapsulate them, followed by a final curing.

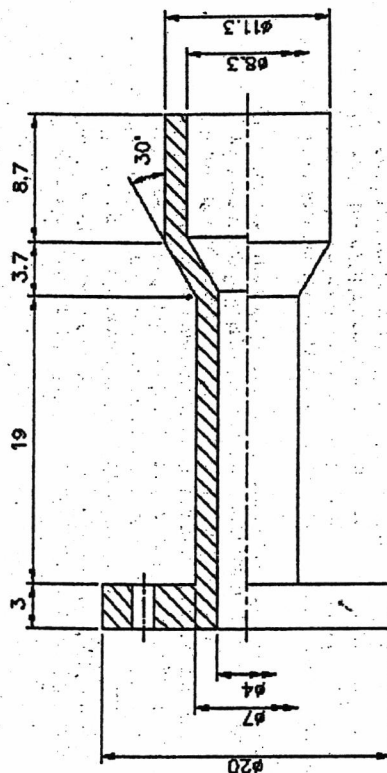
The epoxy that RS sells is far too coarse for mounting the diode - it seems to be of a gritty composition (although it is satisfactory for mounting PCBs etc). The Epo-Tek is finer and considered more suitable for securing the diode.

One query was the exact shape of the 6 mm aluminium block above the 47 GHz mixer board, specifically how the microstrip line feed passes through to the 4 mm dia waveguide. It was thought that this should be a slot just larger than the line. DB6NT confirmed this, the slot being approximately 0.6 (h) x 1.8 (w) mm over the microstrip line.

ANTENNAS

G7MRF and G4CBW decided to use 10" dishes with an f/d of 0.37, with a 60mm diameter "splash plate" feed. This is fed by approx. 100 mm of K&S 3/16" round tube (4 mm ID) with a circular flange used to connect to the transverter. To aid alignment of the waveguide to the transverter, a length of K&S 5/32" tube (fits inside 3/16" tube) was cut to just under the 100mm and a collar of 3/16" tube soldered to it to act as a stop, to prevent hitting the pcb down the 4mm hole in the transverter. This then allowed the dish waveguide feed to be positioned accurately before tightening the flange screws on the transverter.

Figure 3 - W2IMU feedhorn for 47GHz



GOIVA decided to use one of the ex-BSB Channel Master 35 cm offset fed dishes (f/d approx. 0.7). A W2IMU dual mode feedhorn was calculated for 47.088 GHz. The waveguide feed to the horn actually calculates to be approx. 4.5 mm. This value agrees with standard circular waveguide sizes recommended for 47 GHz. However since the 4.0 mm hole has been used on the transverter successfully, the waveguide feed to the horn was left at 4.0 mm. G7MRF turned the horn up out of a solid piece of brass, as it seemed too small to try making up from bits of tubing. This was mounted via its flange directly on the 47 GHz transverter body. An aluminium plate was made up that acted as

a cover for one half of the transverter and a mounting plate for the 12 GHz LO. This whole assembly was then positioned to place the horn at the dish focal point, with some adjustment available for fine-tuning.

INITIAL RESULTS

Initial testing was carried out over about 50 feet in G0IVA's garden. A signal source was used consisting of a "brick" phase locked oscillator (at approx. 11.772 GHz) with an external multiplier consisting of a sma connector and "blue cap" LNB mixer diode on the output as per G3PYB. This resulted in S9 signals over the 50 feet. Removal of the external multiplier resulted in signals being about S1-2, this being a "leaked" harmonic from the PLO. This signal level was found to be convenient for getting the feel of the dishes and for adjustments. The 5mm (G0IVA - 2BA) waveguide short was tuned for maximum signal on receive using a spectrum analyser on the IF. This was found to have very broad tuning with no well-defined peak. All the transverters were finally set with the end of the screw approx. 3.5 mm above the pcb, with some adjustment available either way. This could need further adjustment depending on the waveguide etc. attached to the transverter.

After these initial tests some brief tests were carried out on 7 March in 'poor weather' conditions of snow, sleet and rain. However these resulted in two ways between G7MRF/P and G0IVAP over approx. 21 km with 57 reports using NBFM and SSB and one way with G0HNW over the same path with 59 signal on 47 GHz using NBFM. G0HNW was using his 24 GHz transverter with a doubler at the dish feed (24"1) with QRO of several milliwatts.

Some further tests are planned for the near future with a view to increasing the distance from these humble beginnings! See Peter's (G3PHO) web site for some pictures of this operation with some close-ups of the gear.

FUTURE PLANS

The tests have highlighted the need for a high stability frequency marker for use when out portable in inclement weather. Paul, G0HNW, has been experimenting with the DF9LN oven controlled crystal oscillator (OCXO) over the winter with some success. These are to be tried in conjunction with a DD004 (with crystal osc section inoperative) as a marker, with the external diode multiplier mentioned above. These OCXOs could also be used in the local oscillator for the 47 GHz transverters themselves if required.

Based on G0HNW success, using the DB6NT doubler, a useful facility would be to have a CW/NBFM source of a several mW that could be either used for transmit (transverter for receive) or at least used for dish alignment.

Currently work pressures restrain G4CBW from participating in the initial tests. Due to this he has loaned his 47GHz transverter to David, G8VZT, so he can participate in all the early trials. G8VZT is also building NB equipment again using 1296 IF with a 35cm offset dish using a feed horn similar to G0IVA.

If there is anybody else interested in having a go at 47GHz but find the enclosure a bit of a problem then contact G7MRF (QTHR) who has a "tame" machinist who can manufacture either to suit a 144 IF or 1296 IF. Also contact G7MRF for the details of the feedhorn used with the ex-BSB dish.

CONTACTS

RF ELETTRONICA di ROTA FRANCO,
Via Grandi 5, 20030 SENAGO - MILAN,
ITALY.

Eisch Electronics
Microwave Committee Components Service
Kühne Electronic (DB6NT)

HP HSCH-9251 Mixer diode

DB6NT 12 GHz LO klis/ pcbs, DF9LN OCXO klis/pcbs
DB6NT pcbs, DD004, WDG009
DB6NT pcbs and ready made units!

A MONTH ON 47GHz ... the email chronicles

The following selection of emails details the remarkable sequence of events leading to the establishment of a new UK 47GHz distance record over the period 7 March to 4 April 1999

From: David Woodward [g0iva@dmwoodward.freemove.co.uk] Sent: 07 March 1999

Today (Sunday 7 March) Martin G7MRF, Paul G0HNW and myself David G0IVA (assisted by Vinny G7OKU) ventured out to have a go on 47 GHz. The weather at our respective homes before setting out was not very promising with continuous rain, but we decided to give it a go anyway!

Paul set up at Bradwell Moor nr Castleton (SK143794/IO93CH) and Martin and I set up near Merryton Low (SK040613/IO93AD). Paul had not yet finished his 47 GHz transverter but was able to generate a signal using his 24GHz gear and a multiplier at the dish feed. Martin and myself both had complete transverters (DB6NT - Martin's using a 1296 MHz IF) - with a best dx so far of about 60 feet!

After using 24 GHz for alignment, 'MRF' and 'IVA' were both able to receive 'HNW's signal at 59+. Paul was able to transmit NBFM. Crossband 144/47 GHz QSOs were easily completed over the 21km path.

G0IVA then relocated next to G0HNW on Bradwell Moor (IO93CH). G7MRF staying at Merryton Low and, after using HNW's signal to net onto, 'MRF' and 'IVA' were able to complete on 47GHz two way with 57 signals (SSB and NBFM tried) at 21 km. G7MRF could copy G0IVA's signal on open waveguide. At the time of the test, the weather was very poor with visibility at Merryton Low down to a few yards with considerable snow/sleet at times - hardly ideal for 47 GHz!

One interesting thing noted was the back scatter from the snow/sleet when 'IVA' was listening to 'HNW's signal. The two dishes were beaming the same way but spaced about 70 feet apart. The backscattered signal had a similar sound to reinscattered signals on 10 GHz but with relatively light snow/sleet at the time. Shielding the main beam of the dish killed the backscatter signal but I could then just hear a nice note from 'HNW direct. This initially caused some concern as I thought my LO had suddenly become very rough!

No further tests were made as the weather was very poor and some of the higher roads were closed due to snow.

We will have another go soon to try and extend the distance a bit - preferably in better weather! (SEE NEXT EMAIL I ...ED)

From: David Woodward [g0iva@dmwoodward.freemove.co.uk]

Subject: 47 GHz outing over Easter leads to new UK record!

Sent: 05 April 1999

G0HNW, G7MRF, G8VZT and G0IVA (with G7OKU) went out on Good Friday (2 April) for some further 47 GHz tests.

Sites used:	ngr	Callsign
Winter Hill	SD867120	G0HNW/P
Sutton Common	SJ934677	G0IVAP
Mow Cop (northern end)	SJ868587	G7MRF/P, G8VZT/P, G0IVAP
Esclusham Mountain	SJ262514	GW0IVAP

Paths worked:

Winter Hill - Sutton Common	51.7 km	59 both ways SSB and NBFM
Winter Hill - Mow Cop	57.0 km	59 both ways NBFM G0IVA
		59 high power TX G7MRF8 G8VZT
		51/57 SSB
		41/56 NBFM
Winter Hill - Esclusham Mtn	72.9 km	59 both ways NBFM
		and new UK 47GHz record!
Esclusham Mtn - Mow Cop	61.0 km	53/54 both ways SSB and NBFM

Weather:-

Very wet at start with fog/mist/cloud. Cleared up a bit later with sunshine but very poor visibility due to haze and mist. Temperatures about 19 deg C.

Conclusions:-

As can be seen above there is a question mark over why G7MRF and G8VZT were weaker than G0HNV when working GWOIVA. Also when G0IVA was co-located with G7MRF and G8VZT, G0IVA and G0HNV were working each other with much stronger signals. This suggests there may be a problem in the 1296 MHz matching network used by G7MRF and G8VZT (using G4CBW's transverter head unit) and also the large PCB pad on the IF port of the mixer pcb. G0HNV had previously made some measurements and reduced the pad size, discarding the matching network. This is currently under investigation by G7MRF.

Based on the signals exchanged between GWOIVA/P and G0HNV/P there was considerable strength in hand. In fact G0HNV could still just copy IVA's signal on open waveguide suggesting signals at least 35 dB above noise over 73 km!

Meanwhile things were stirring down South.....

From: John Hazell [hazell@mcmall.com] Sent: 04 April 1999

I have just finished my 47G transverter and Peter, G3PYB was kind enough to do tests with me using his gear. Today we tried first from my garden to a bridge over the M3, roughly 3 miles away and visible from my garden. Peter was 50+ and my report was RS55.

Then I moved to a local PMR site, Crabwood and Peter went to my usual portable site, Lane End. This turned out to be an obstructed path. It was just a stop-off point whilst Peter was on his way down to Portsmouth Hill at Portsmouth so not vital in any way. His signal was OK with me but with multiple peaks from the dish panning around the obstruction(s). Peter could not hear me. Peter then arrived at Portdown Hill, about 31km from my local Crabwood PMR site. He was again RS55, easy noise-free FM copy. Peter still could not find my signal! My o/p power is 350uw total spg out!! so hopefully 150uw of that will be the wanted 47088MHz. Interestingly, once Peter had aligned his dish I could hear him from each location using just the little feed horn on my transverter unit.

So maybe 47G is easier than you might first think? Altogether this was a very pleasing first set of tests and thanks to Peter, G3PYB, of course.

The 47GHz transverter, by the way, is a G8ACE variation of the DB6NT, using all my own LO circuits giving about 50mw LO drive at 23.9Gish. The IF pre-amp is the DB6NT 24G IF circuit using a BFG67 transistor and HP PIN switching (Farnell) and the transverter is the DB6NT but with two individual diodes for the mixer (HP) all PCBs printed by me using the laser jet method.

73 from John, G8ACE.

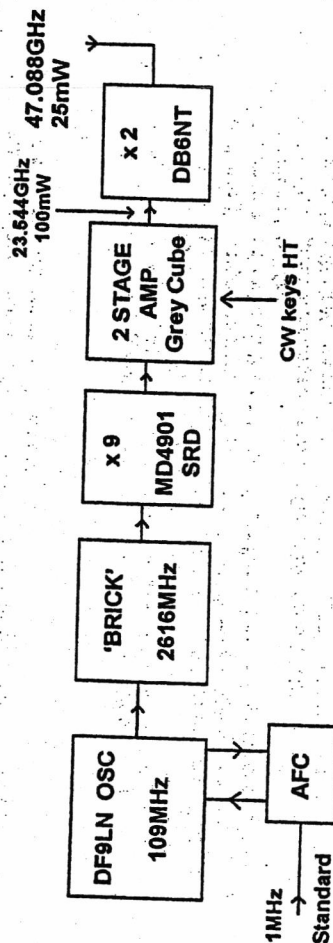
Web Sites: www.microwaves.mcmall.com/ and www.hazell.freearve.co.uk/

THE G0HNV 47GHz UK RECORD BREAKING EQUIPMENT

The following notes outline the equipment used by Paul Widger, G0HNV, to establish a new 47GHz UK record over the Easter weekend in April 1999. Paul is a "no frills, no messing about" experimenter, preferring to get on with the job of building and then operating the necessary equipment rather than spend months thinking and theorising about it! The proof of his philosophy is evident here, as his gear certainly works!

THE EQUIPMENT IS A TWO PART SET UP:

1. The CW and FM "Beacon"



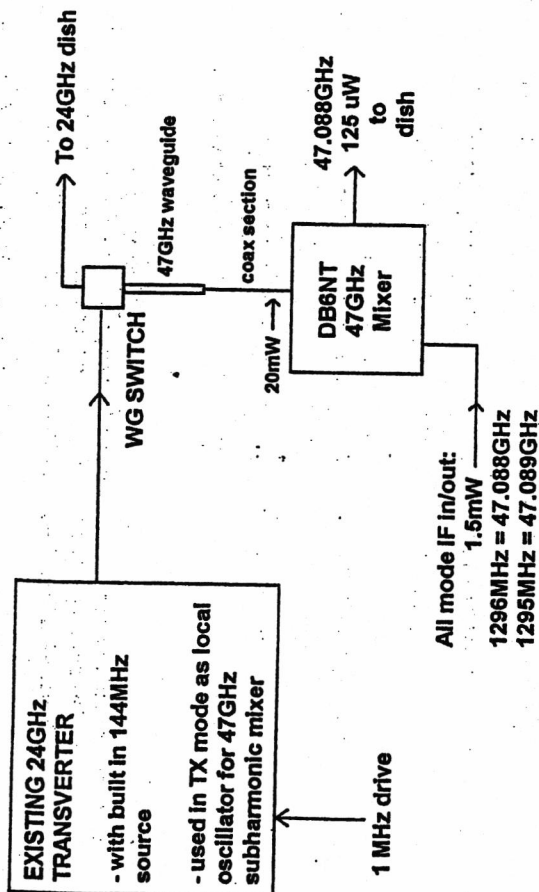
The DB6NT doubler used in the beacon is mounted directly at the dish focal point. The output of the "Grey Cube" (23GHz DMC module) is enough to allow coax to the doubler input. The dish f/D is 0.375 so 4mm i.d tube made an ideal circular horn feed.

The beacon can be used alone as a test source or as a higher power TX with a transverter. It can also be locked to my external 1MHz, ovenized crystal oscillator, slightly offset, to give an accurate marker at 47088.100MHz.

Surprisingly I found the DB6NT 23.5/47GHz doubler will act as a power mixer! At the monitor point feed in a low frequency, I even tried 10mW of 3.5MHz and 100kHz. This resulted in a little less than 1 milliwatt of SSB output !!

2. Transverter

The following diagram shows the simple 47GHz transverter which utilises my existing 24GHz transverter. This serves as a driver/oscillator to feed the DB6NT 47GHz subharmonic mixer. It has a built-in 144MHz source and is used in the TX mode in the 47GHz application. An IF of 1296MHz is used, with reverse tuning. There is a lot of RF in reserve using this method and thus less new gear has to be built to get on the air, avoiding the possibility of having to throw away newly built modules that do not work properly! Operators with rigs that will not tune below 1296MHz can alter the 144MHz source in the 24GHz system to suit. A 144.500MHz source will



give 1297 - 1296MHz IF.

The 24GHz dish is also used on 47GHz. It is first aligned on the other station using a 24GHz signal. Thus dish headings for 47GHz are "dead on".

The DB6NT mixer is a "cut down" version of the normal module no multiplier (12-24GHz) or IF switching is necessary at the dish feed.

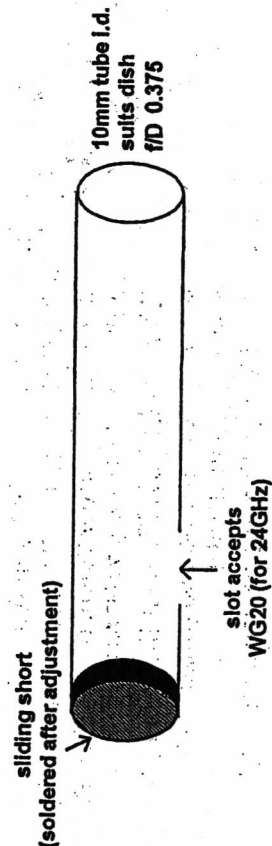
The output of the 144MHz source can be varied to suit the DB6NT mixer drive level.

20mW seems to be optimum for both TX and RX.

24GHz can be run on its own internal frequency standard or locked to a superior, external 1MHz standard for greater stability and accuracy.

The Dish

This is a 60cm diameter antenna with a J hook feed, originally made for 19GHz. I modified it for 24GHz by inserting a length of 10mm i.d. tube whose outside diameter suited the J hook feed. It is slotted to allow the waveguide to enter and is fitted with a sliding short for match adjustment.



47GHz Spectrum Analyser

A "Grey Cube" Mark 2 mixer will act as a harmonic mixer for 47GHz. Feed 47GHz down a 4mm i.d. tube with transition to sma near an end with a sliding short (optional) and a probe of some 0.05 inches. Set a Grey Cube DRO module to approximately 23GHz to give an IF of 1100MHz, very suitable to "look at" on a basic Spectrum Analyser.

Results so far

With the Beacon feeding 25mW into "open waveguide" only:

3.5km path (LOS) = 66dB fade margin

28km path (LOS) = 40dB fade margin (15mW of 24GHz to open waveguide gave 46dB fade margin in this path)

Using the DB6NT transverter feeding 125 microwatts into a 60cm diameter dish:

Fade margin measured as just workable on CW. A 4dB increase gave easy copy.

Receive Tests:

1.4dB of sun noise measured at 47GHz. 0.5dB of sky to ground.

The 60cm dish appears to give 35dB gain over the open waveguide.

I do not know if the dish surface is good enough for 47GHz but it's all I've got!

EDITOR'S COMMENT:

It now looks as if 47GHz is finally receiving some attention in the UK. Elsewhere in this issue is news of experiments in the South of England, between G3PYB and G8ACE. To our knowledge there are at least another ten sets of working 47GHz equipment in the hands of UK microwavers but alas very few have ever been used in earnest! Let us hope that the 47GHz information and news published this month will encourage others to have a go.....

STOP PRESS!!

Just as this issue was going to press we heard the news that G0IVA's and G0HNW's UK 47GHz record of 73km (see page 10) was extended still further when, on Sunday, 18th April 1999, during the 24/47GHz Contest, G0IVA worked G7MRF over the 90km path between the Stiper Stones (IO82NM) and Merryton Low (IO93AD).

More on this fine achievement will

Le 76 GHz

76 GHz Station

Peter Riml, OE9PMJ

The 76 GHz-Station is very similar to the 47 GHz station in DUBUS 3/89. The mixer diode however functions as a x5 multiplier. The diode used is a BAT14-123. Output power is some uWatts only. Noise figure is estimated at about 40 dB. The diode current is about 40 mA during transmit and 3 mA during receive. Carrier frequency of the second station has an offset of 145 MHz (IF-Frequency) and both crystal oscillators are modulated in F3.

Antennas used are dishes with 35 cm diameter and an estimated gain of 46 dBi. Maximum range so far is about 3 km. Thanks to Hubert, OE9HHV, for the precise machining.

Die 76 GHz Station ist in gleicher Weise aufgebaut wie die 46 GHz-Station (DUBUS 3/89). Die Mischstufe arbeitet gleichzeitig als Verfünfacher. Als Diode wird die BAT14-123 verwendet. Die Ausgangsleistung liegt bei wenigen uW und die Rauschzahl wird über 40 dB liegen. Der Diodenstrom beträgt beim Senden ca. 40 mA und bei Empfang ca. 3 mA. Die Trägerfrequenz der Gegenstation ist um 145 MHz (ZF) versetzt. Die Quarzoszillatoren werden frequenzmoduliert (F3) für Fone bzw. umgetastet (F1) für CW.

Als Antennen sind 35 cm Parabolspiegel im Einsatz. Mit ihrem Gewinn von 46 dBi erlauben sie eine Reichweite von max. 3 km. Besten Dank an Hubert, OE9HHV, für die Fräsarbeiten.

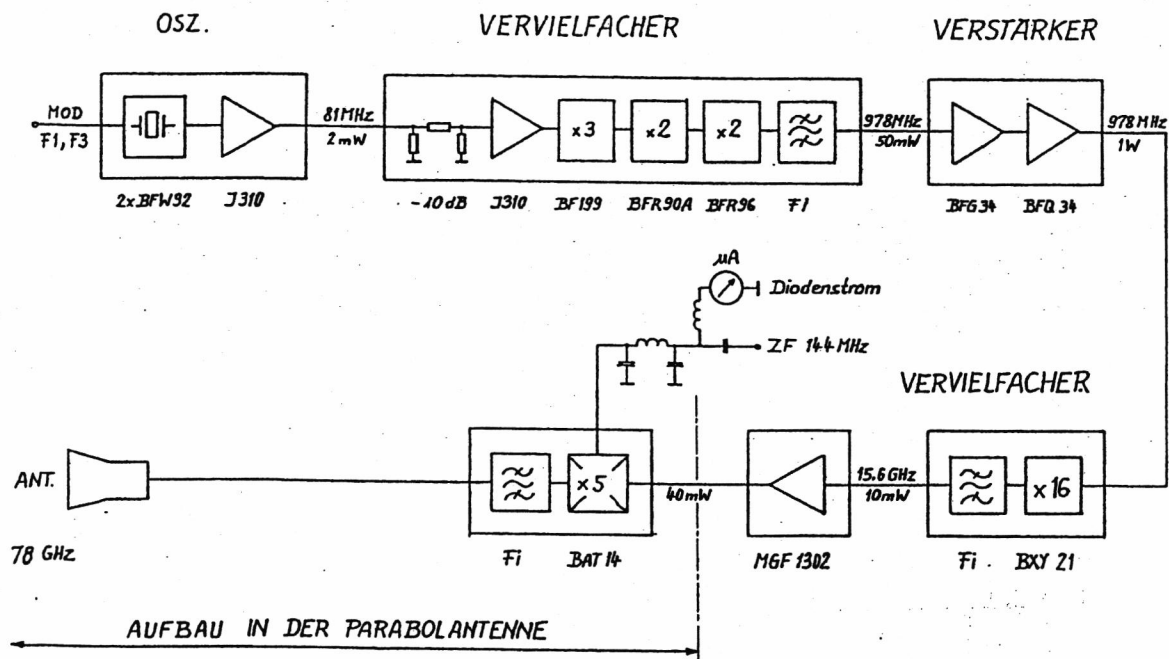
DUBUS 4/89

18

76 GHz TRX

BLOCKSCHALTBIID

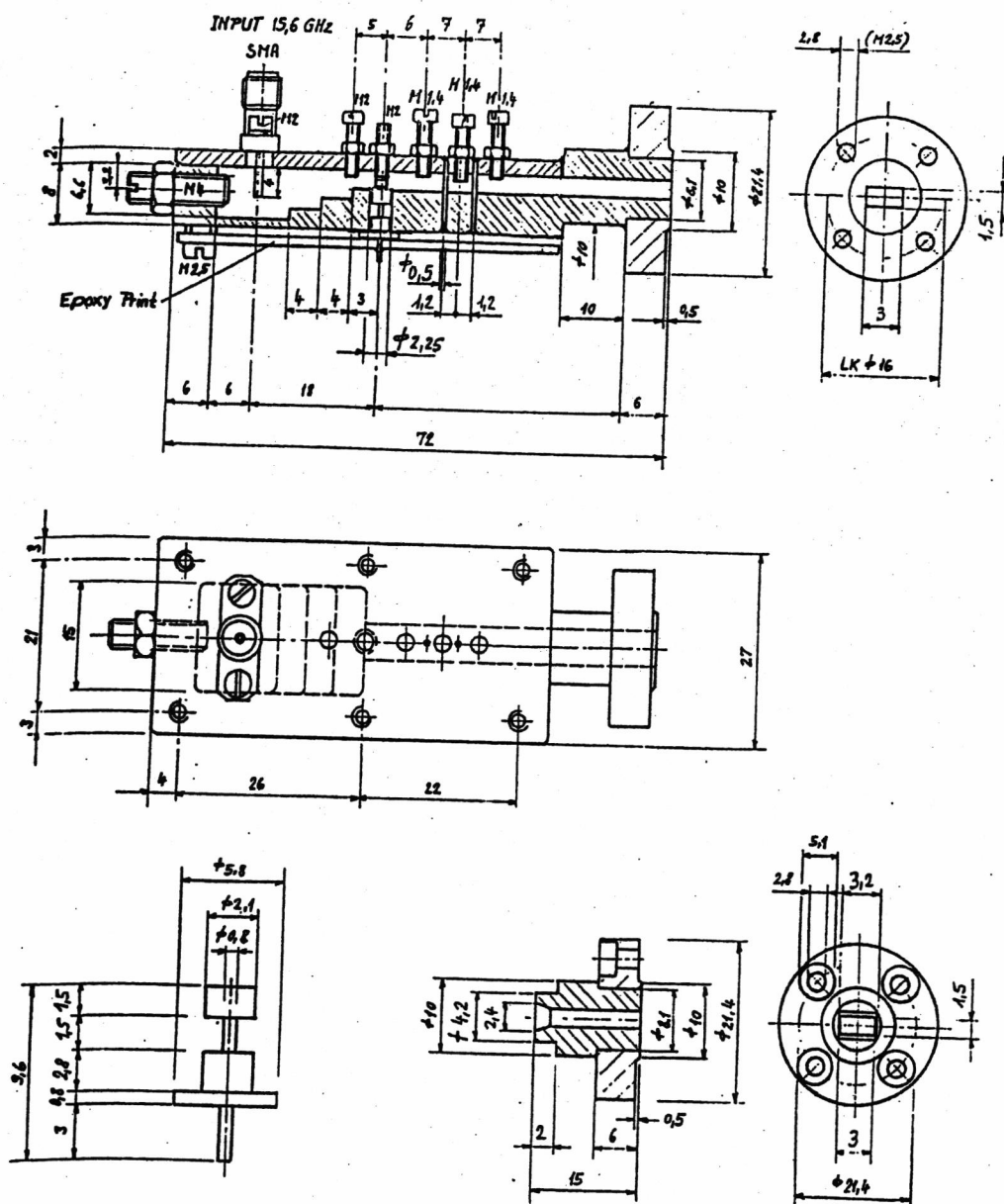
OE9PMJ



Technical Reports: 76 GHz Station by OE9PMJ

Figure 1/Bild1: Block Diagram/Blockschaltbild

Figure 2/Bild 2: Mechanics/Mechanik



A 75 GHz Transceiver

Bob Johnson KF6KVG

This transceiver is assembled from mostly commercial parts collected over time at electronic flea markets. Some critical and scarce items were loaned by Will Jensby WOEOM. Here are the technical details of the completed system.

Specifications are:

Frequency TX and RX: 75,600 Mhz

Power of transmitter: +8 dbm

Effective receiver LO frequency: 76,160 Mhz

Noise figure of receiver: approx. 20 db

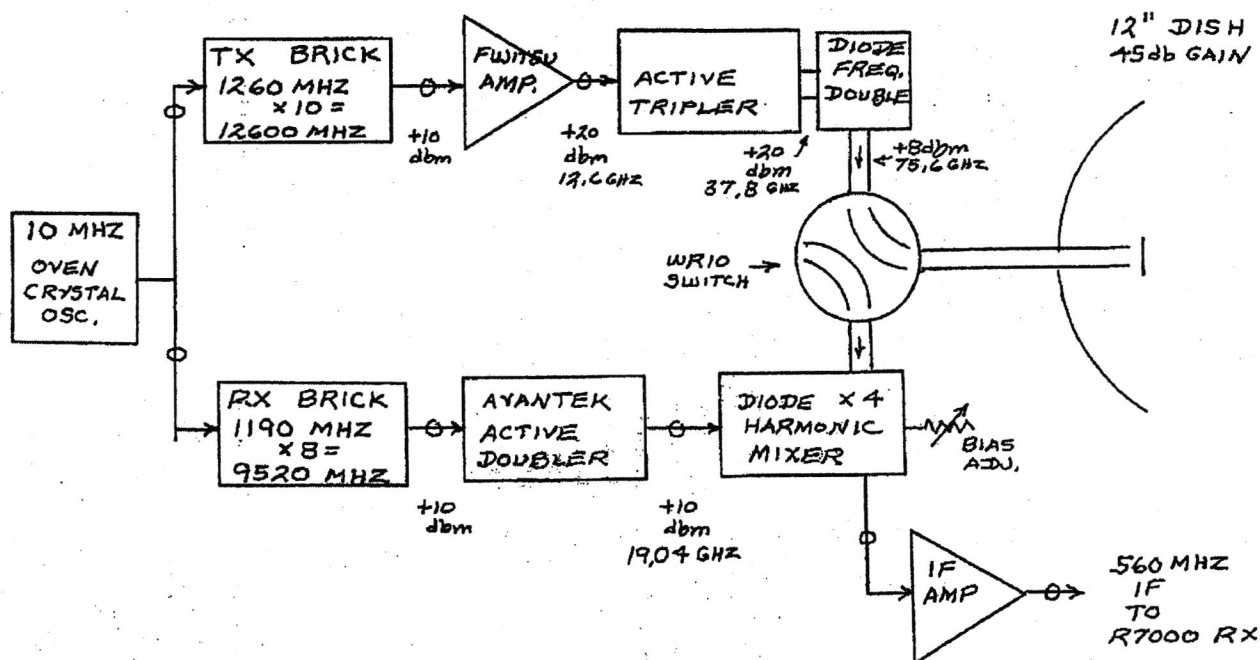
Antenna gain: 45 db

Antenna beamwidth (3 db): 1 degree

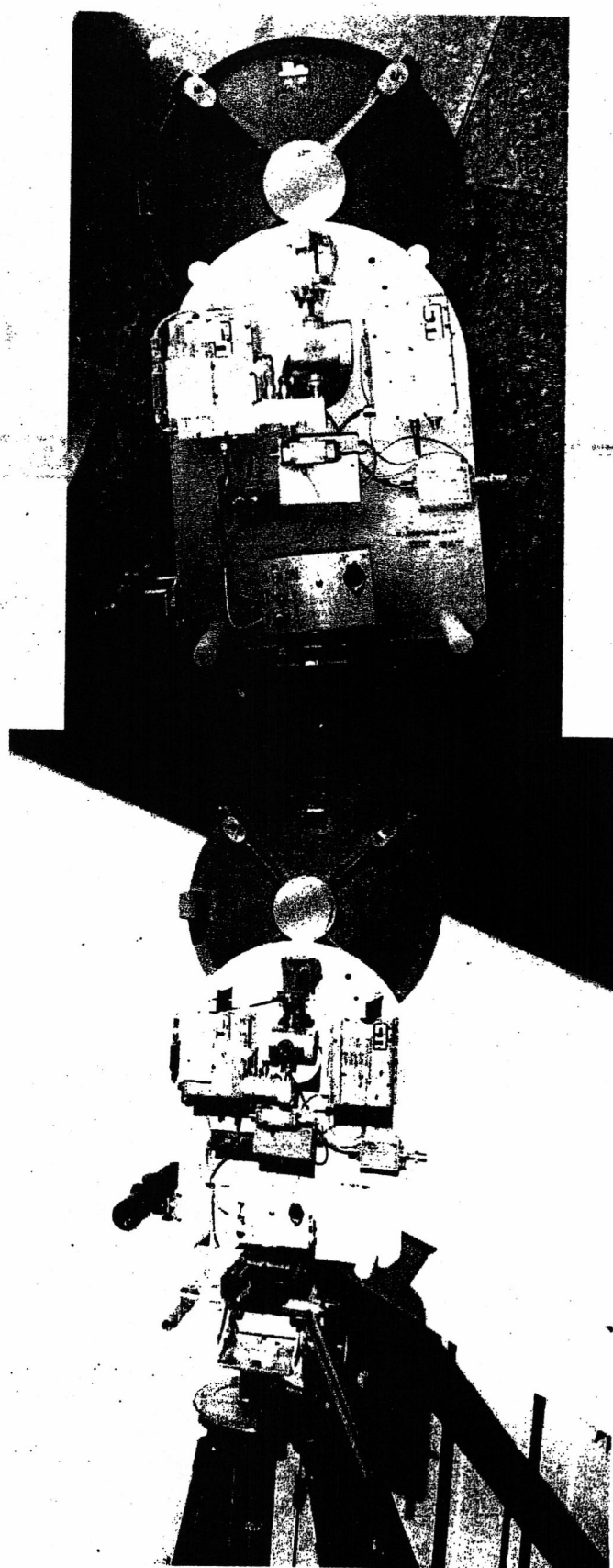
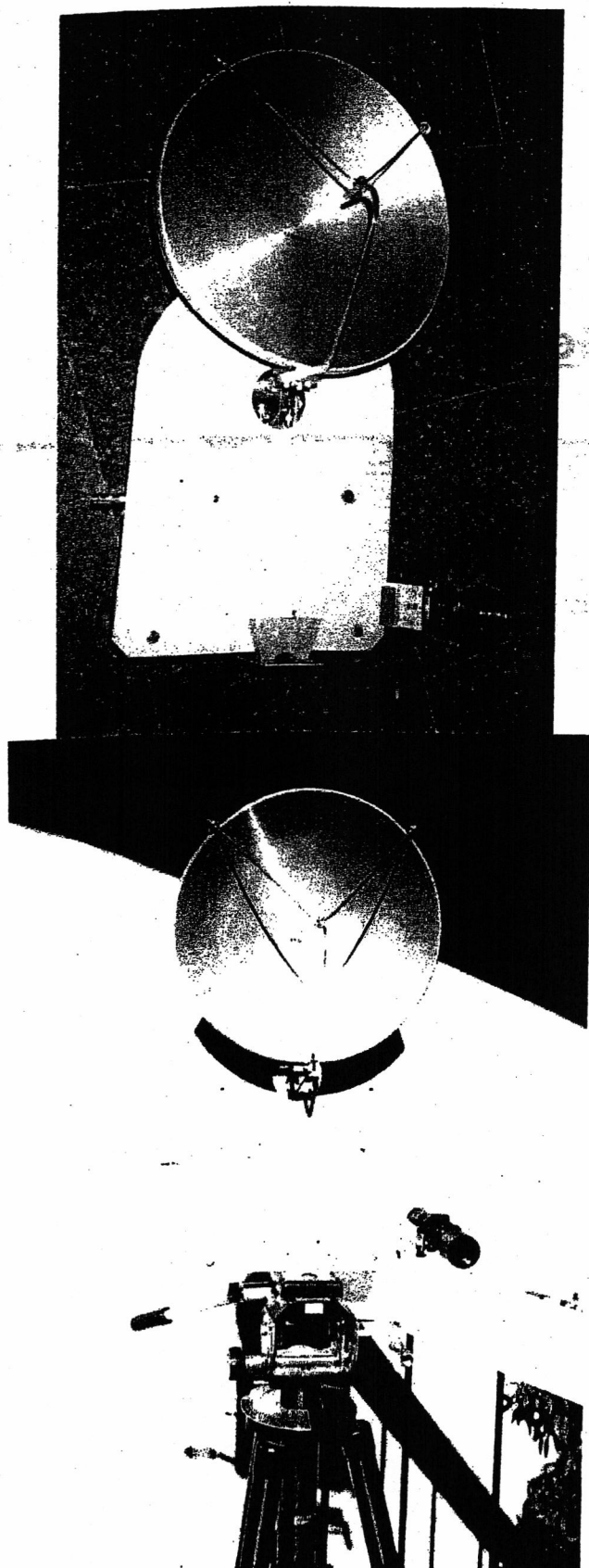
The block diagram shows the major components and their relationships. It starts with an oven stabilized 10 MHz crystal oscillator, which controls both transmit and receive frequencies. This insures frequency stability better than 100 Hz at the 75 GHz ports. Both TX and RX bricks (phase locked oscillator-multipliers) are locked to the 10 MHz reference. The TX brick base oscillator runs at 1260 MHz, followed by a X10 multiplier and filter. The 12.6 GHz product at 10 dBm level is boosted to 20 dBm using a Fujitsu amplifier. A Milliwave active frequency tripler is next, increasing frequency to 37.8 GHz. The 20 dBm power generated by the tripler exits in WR28 waveguide. A tapered waveguide section, formerly part of an HP multiplier, narrows the E-plane down to a slot where it butts onto a point contact diode flange. One side of the flange sees the 37.8 GHz drive, and the other side exits the second harmonic 75.6 GHz into a WR 10 guide. This guide bolts directly onto a WR 10 transfer switch which feeds the 8 dBm @75.6 GHz out to the dish antenna.

The receive brick, also locked to 10 MHz, produces 1190 MHz. This is multiplied and filtered within the brick to yield 9520 MHz at 10 dBm. An Avantek active frequency doubler then kicks this up to 19.04 GHz with a 10 dBm level for driving our harmonic mixer. (Or also called downconverter) The fourth harmonic of 19.04 GHz becomes our effective LO frequency of 76.16 GHz. Conversion loss is about 20 dB. This mixer is one of the scarce parts, and the fragile diode inside can die with no known cause. Mixing product from 75.6 GHz signal and 76.16 GHz LO is our 560 MHz IF frequency. A low noise IF amp with 28 dB gain boosts signal noise to where the R7000 S-meter gets off the bottom stop. When receiving a weak signal as during antenna pointing, we rely on the tone heard in SSB mode. This is also the narrowest band width for the R7000 and gives the best S:N ratio.

The system runs on 12 volts, converted to 10 v. and 24 v. in a separate power unit. A toggle switch connects power to bricks, amps, and multipliers as needed for TX or RX. The antenna is a precision 12 inch dish with a WR12 buttonhook feed.



BLOCK DIAGRAM
75 GHz TX/RX

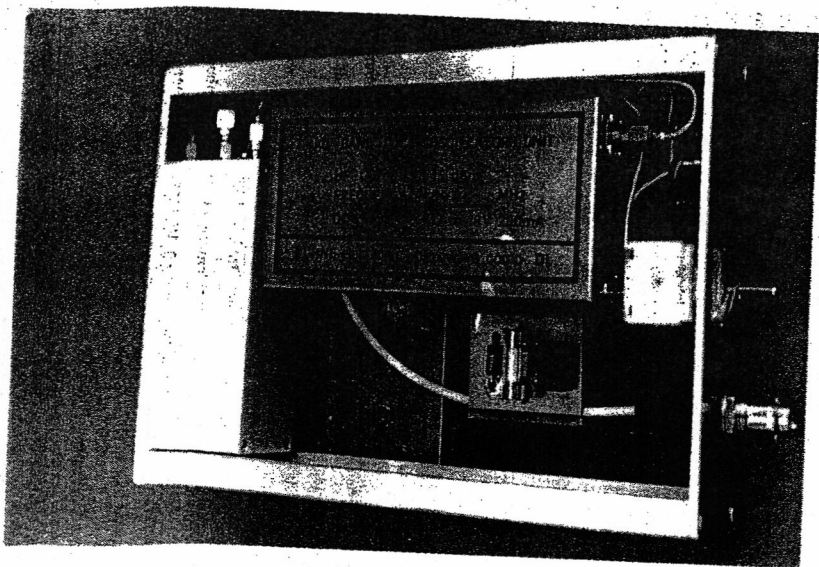


Technical Reports

by DJ9BV, Rainer Bertelsmeier, Glücksburger Str. 20, D-2000 Hamburg 50, FRG

Transverter for 76 GHz

Michael Kuhne, DB6NT
Birkenweg 15, W-8674 Naila 2



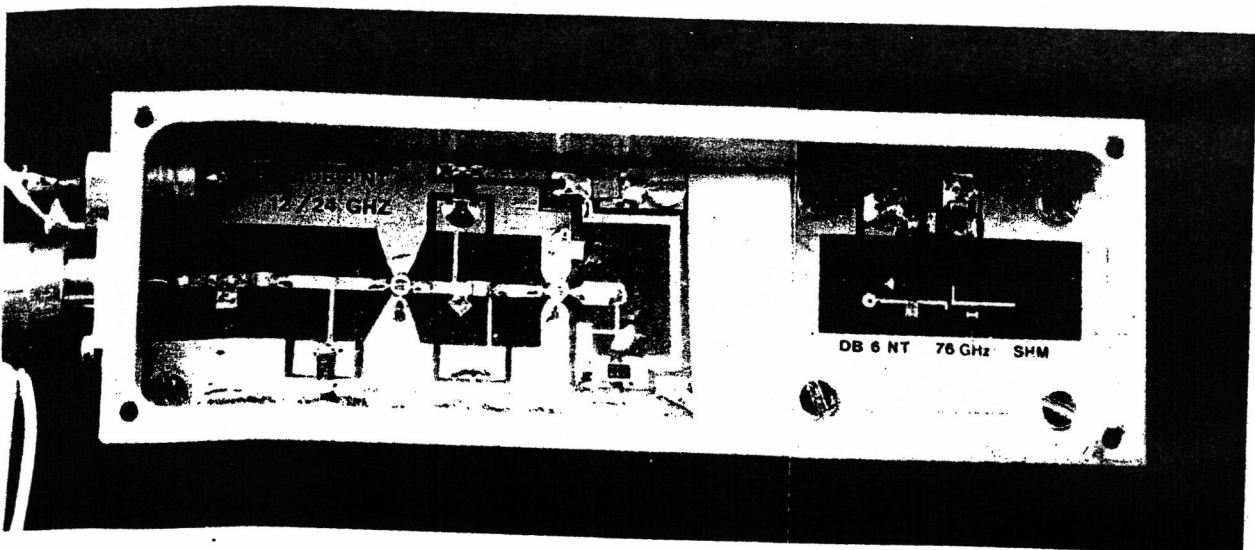
Bild/Figure 1: 76 GHz Transverter

Kurzfassung: Der 76 GHz Transverter besteht aus einer SHF-Baugruppe, die mit einem Subharmonischen Mischer mit einer Beamlead-Diode bestückt ist, und einer 9,486 GHz Oszillatorbaugruppe, die über einen Verdoppler den Mischer speist.

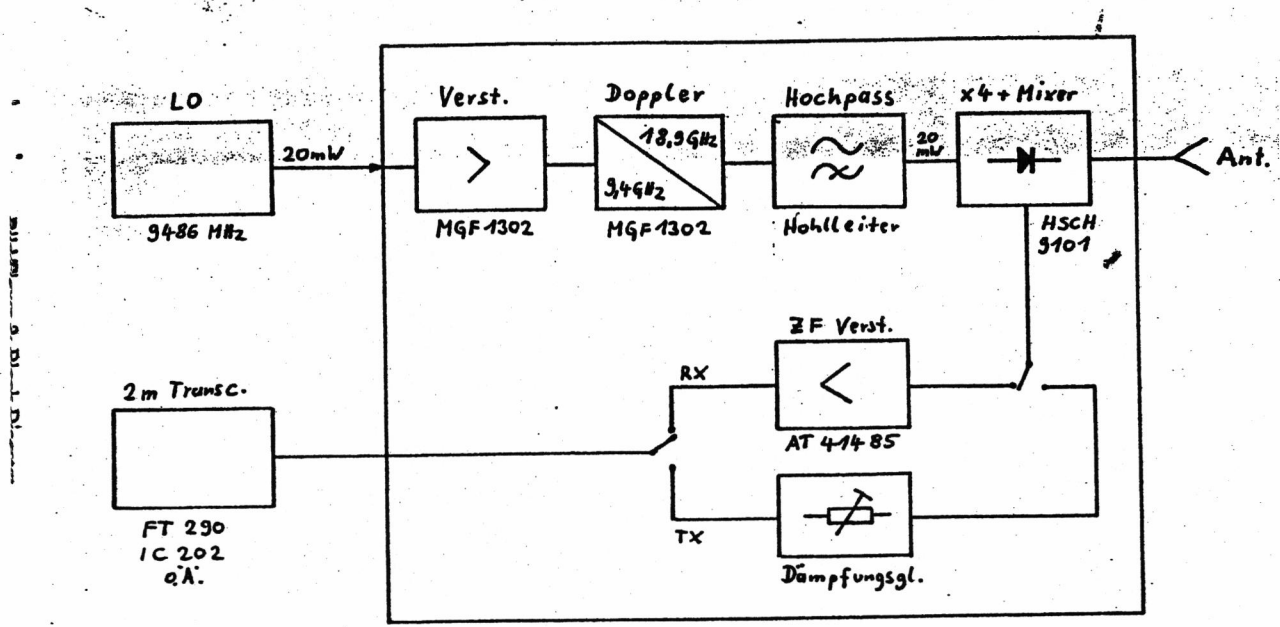
Abstract: The 76GHz transverter uses a subharmonic mixer with a beamlead diode on a teflon substrate. A 9.486GHz LO feeds the mixer via a doubler and waveguide high-pass filter.

1. Design

Das LO-Signal (9,486 GHz) wird in T1 verstärkt, mit T2 verdoppelt und liegt am Mischer nach dem Hochpass mit ca. 20 mW an. Der Hochpass ist als Ausföhrung im Hohlleiter realisiert und verhindert die Einkopplung von 9 GHz Signalen in den Mixer. Die Einkopplung in den Hochpass und vom Hochpass auf dem Mischer erfolgt über Kopplstifte (siehe Bild 9). Der Mixer arbeitet mit der Beam-Lead Diode HSCH-9101 (siehe Datenblatt) und ist auf einem 0,125 mm dickem Te-



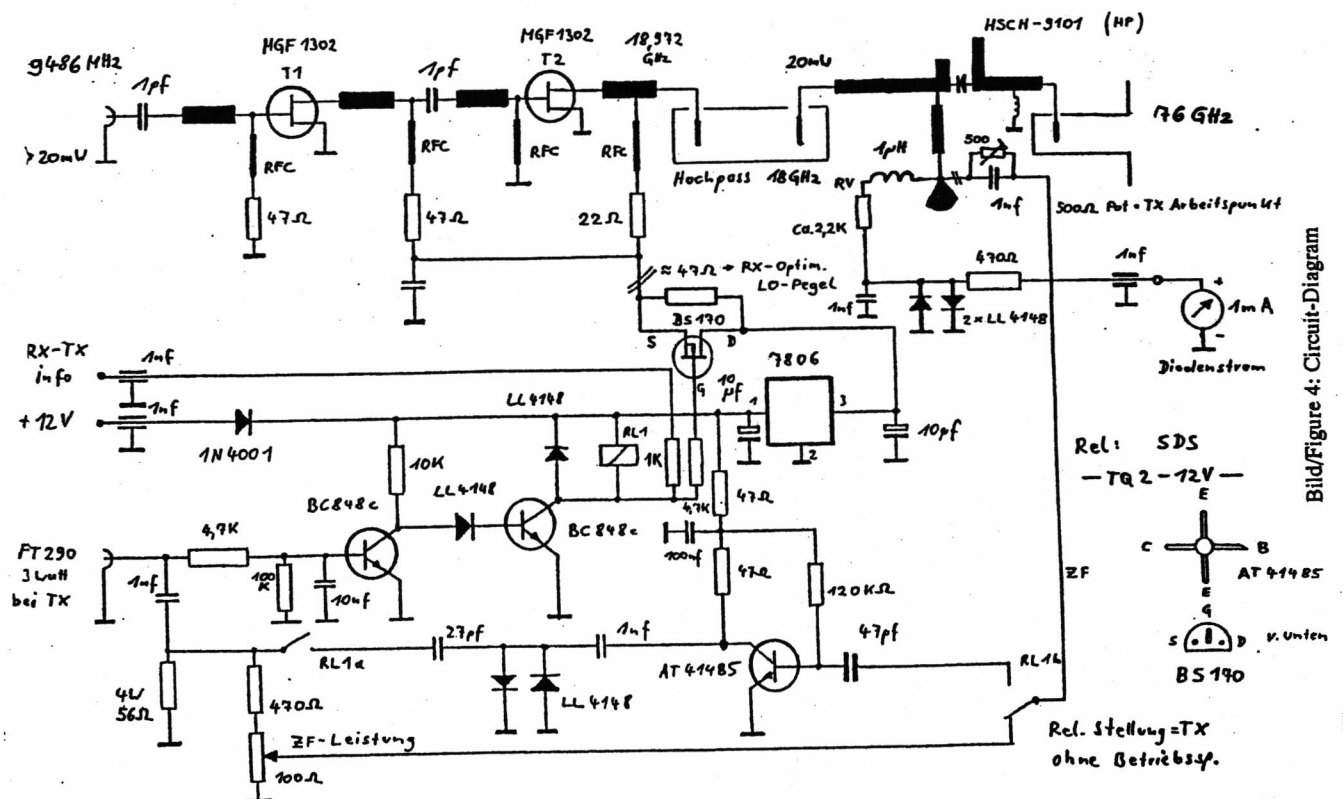
Bild/Figure 2: LO-Doubler and 76 GHz Mixer



76 GHz Lineartransverter

DB 6 NT 10.91

x 4
+ Mixer



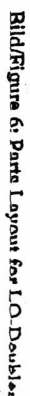
Bild/Figure 4: Circuit-Diagram



Flon-Substrat aufgebaut. Die Auskopplung auf den Rundhohlleitern erfolgt am Ende der Stripline (Bild 9). Der Hohlleiter ist eine 2,6 mm Bohrung im Gehäusen. Der notwendige Kurzschlussblech oberhalb als Blechstreifen oder als M3 Schraube ausgeführt werden (Bilder 9, 12, 13).

1. Design

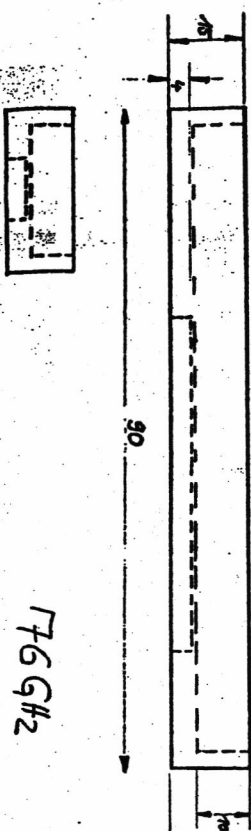
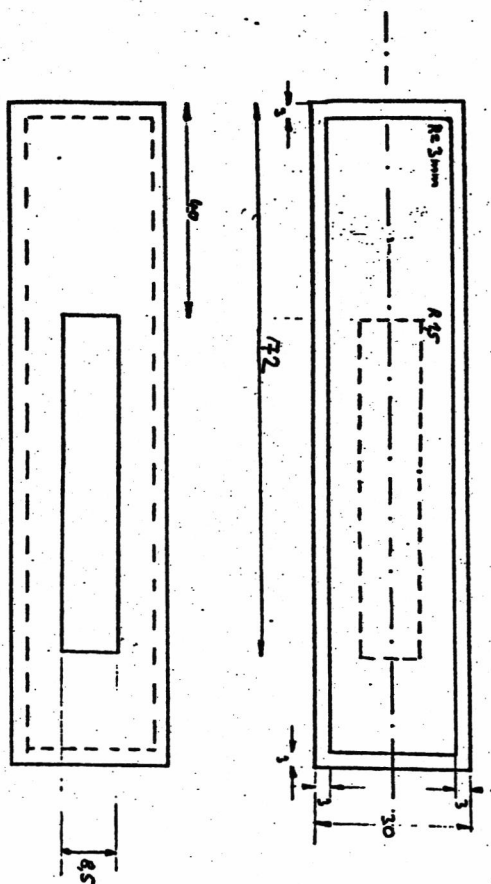
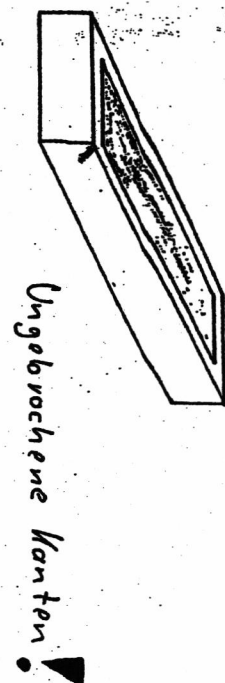
flon-Substrat aufgebaut. Die Auskopplung auf den Rundhohlleitern erfolgt am Ende der Stripline (Bild 9). Der Hohlleiter ist eine 2,6 mm Bohrung im Gehäuse. Der notwendige Kurzschlussblech kann als Blechstreifen oder als M3 Schraube ausgeführt werden (Bilder 9, 12, 13).

[illegible]

Bild/Figure 7: Parts Layout for IF-Board

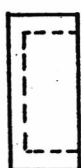
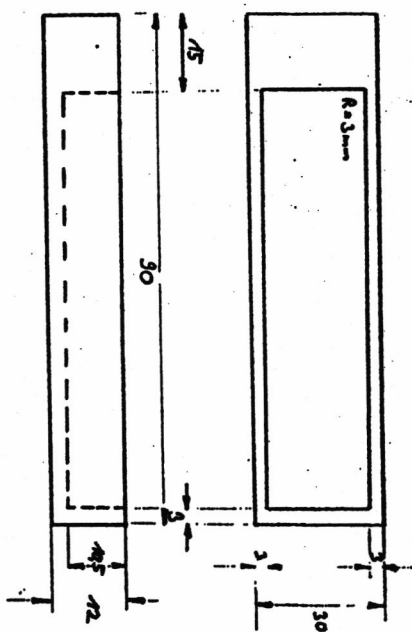
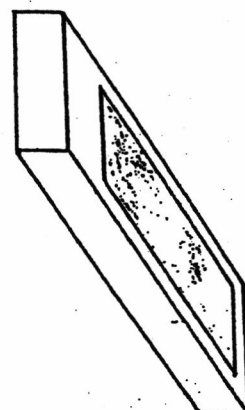
inhibits the feedthrough of 9 GHz power into the mixer. Coupling in and out from this nut is made by coupling pins (see figure 9). The harmonic mixer works with the HSCH-9101 beam-lead diode and is realized on teflon substrate (0.125 mm thick). The output coupling is made by the free end of the output stripline (figure 9), which couples the output power into the 2.6 mm cylindrical waveguide. The shorting stub can be constructed as a small metal plate or as a M3 screw (Figures 9, 12, 13).



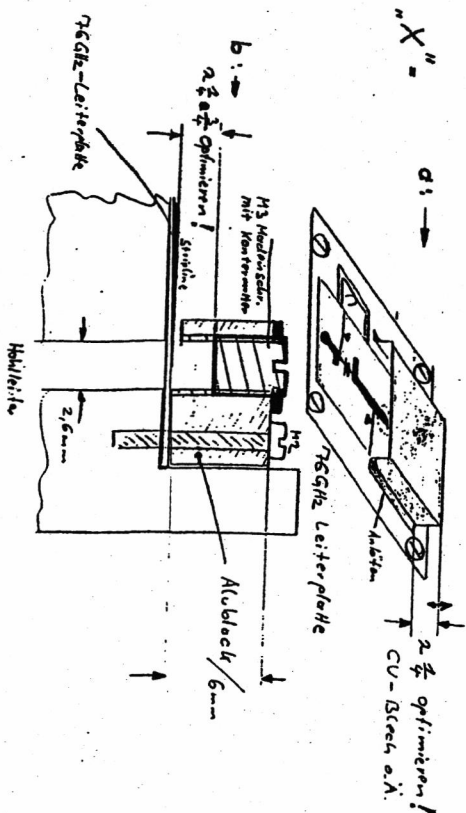
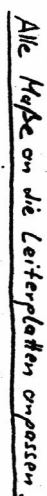


76 GHz
Werkst. Alu

Bild/Figure 9: Mechanical Construction



Bild/Figure 10: Mechanical Construction



DUBUS 2/1992



Bild/Figure 13: Waveguide Shorting Screw

2. Aufbau und Abgleich

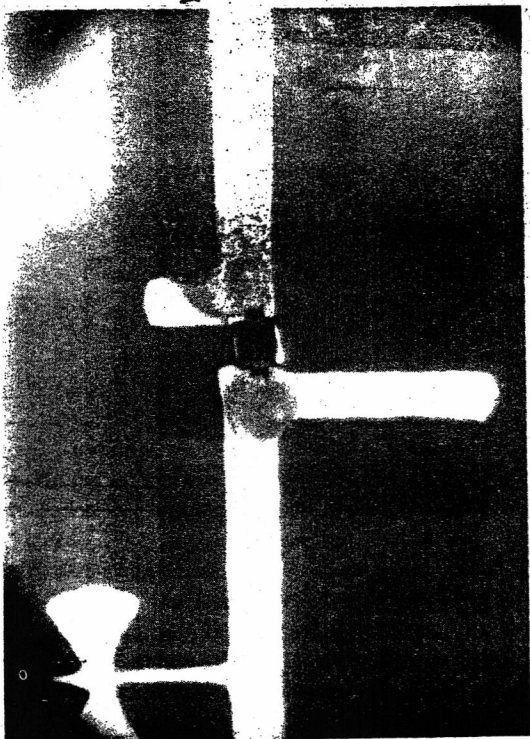
Vor dem Einbau der Mixerplatine ist der Abgleich des Vendopler nötig. An Stelle der Mixerplatine wird über ein Semirigid-Kabel das Bolometer angekoppelt und die Stufen T1, T2 auf maximale Ausgangsleistung optimiert. Für eine gute Masserkontaktierung wird die Mischterplatine mit Silberleitleack versehen und mit M2-Schrauben angeschraubt. Statt mit Bonden oder mit Einfäden werden die Dioden mit Leitsilber-Leitkleber bestrichen. Die Diode wird mit einem feuchten Zahnstocher aus der Verpackung genommen und auf der Leiterplatte in den Kleber gedrückt. (Goldfläche der Dioden zur Leiterbahn!). Danach wird um die zweite Abblösung zu vermeiden, die Anschlüsse der Dioden müssen mit Leitkleber umgeben sein, um eine spätere Ablösung zu vermeiden. Nach dem Aushärten des Klebers kann die Kontaktierung mit einem Ohmmeter geprüft werden.

Die RX-TX Umschaltung sowie der ZF-Verstärker werden auf einer SMD-Platine in die andere Seite des Gehäuses eingebaut (Bild 9). Der ZF-Verstärker ist breitbandig und kann für 144 MHz und 432 MHz verwendet werden. Die RX-TX Umschaltung ist für ein IC202 oder FT290 ausgelegt (+ TX auf dem Innenleiter; IC202 muß umgerüstet werden). Das Dämpfungsglied ist für eine Leistung von 1 ... 3W dimensioniert.

DUBUS 2/1992

Für den RX-Abgleich wird die LO-Leistung auf 19 GHz durch Verteilern der Betriebsspannung zurückgenommen und der Arbeitswiderstand der Diode vergrößert. Der Strom beträgt dann ca. 0,6 - 0,9 mA. Der LO-Pegel wird durch Beobachtung einer Bake optimiert. Die Einstellung erfolgt durch einen variablen Widerstand in der Betriebsspannungsleitung des LO (BS170).

Die Montage der Baugruppe erfolgt direkt auf der Innenseite der Rückwand. Die Hohlleiterbohrung und die M2 Flanschgewinde sollten mit äußerster Sorgfalt ausgeführt werden.



Bild/Figure 14: Close View on the Beam Lead Diode

xet board a bolometer mount is coupled to the LO-board via a semirigid cable. The two stages are tuned for maximum output.

After having tuned the LO the mixerboard is glued into the cabinet with silverpaste and tightened by M2 screws. The next step is the mounting of the beam-lead diodes. Three techniques are in use for this problem: bonding, soldering or gluing. For amateurs gluing is the most adequate technique. Looking at the board with a microscope you have to put some silver paste to the track on the PCB. Then pick up the diode from the package with a wet toothpick and apply it into prepared piece of the track. The gold plated ends of the diode are facing the track! In the same way the second end of the diode will be glued. Take care that the ends of the diode are completely covered by the silver paste. When the silver glue has hardened check the connection with an Ohmmeter.

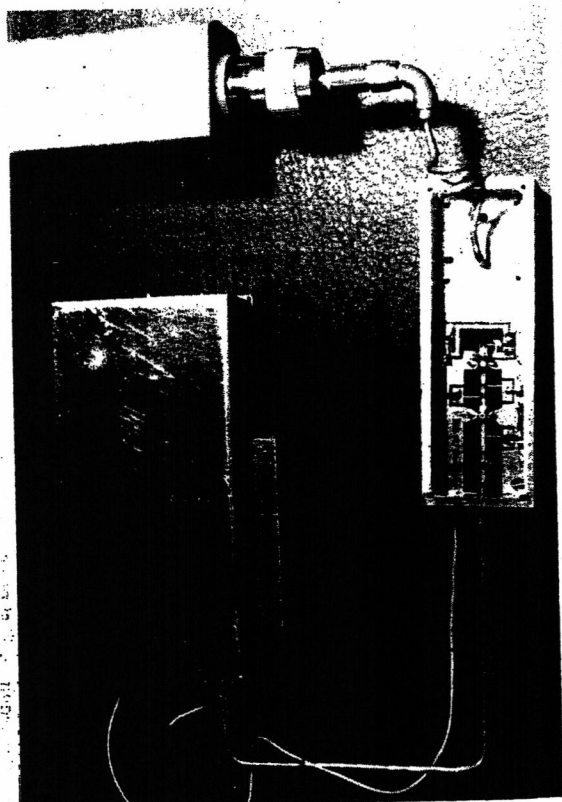
The TR-switch and the IF-amplifier are on second PCB, which is mounted into the other side of the aluminum cabinet. Two holes (1.7mm dia.) serve as a feedthrough for DC and IF. The IF-amplifier is very broadband and can be used on 2 m and 70 cm IFs. The output line takes the switching voltage for a FT290 or IC-2024+ during TX). The input attenuator for TX is rated for 3W maximum.

Tuning of the mixer for transmit can be done by attaching small pieces of copper foil at the coupling point from the mixer to the waveguide. A spectrum analyzer would be a valuable tool at this stage. The driving

2. Construction and Tuning

Die LO-Baugruppe läßt sich ohne weiteres durch Abstimmern der Resonanzfrequenzen auf 9,5 GHz abstimmen. Der letzte Viererfacher arbeitet dann als Verteilfacher.

Before the mixerboard is inserted into the cabinet the LO power on 19 GHz has to be optimized. Instead of the



Bild/Figure 15: Measurement Setup for LO-Power

power can be adjusted with P1. The diode current should be some milliamps. This current can be checked via a small meter on the front plate.

The tuning for receive requires the adjustment of LO-power for optimum sensitivity. This adjustment is performed by varying a series resistor in the B+ line of the LO-doubler (BS170). By observing a beacon or a harmonic of an oscillator the diode current can be optimized. In this condition the current should be between 0,6 - 0,9 mA.

The LO can be tuned to 9,5 GHz easily by turning the tuning screws into the resonators. The last quadrupler functions as a tripler in this tuning condition.

4. Teile/Parts

Beam-Lead-Dioden sind vom Siemens, HP (z.B. HSCH-9101) oder Alpha zu erhalten. C max. 0,15 pF Medium Barrier. Leiterplatten für Transverter vom Verfasser und für den LO bei Dirk Fischer, Neuer Graben 83, W-4600 Dortmund 1, Tel. 0231/105752

PCB for the transverter from the author and for the LO from Dirk Fischer (address see above).

5. Literatur

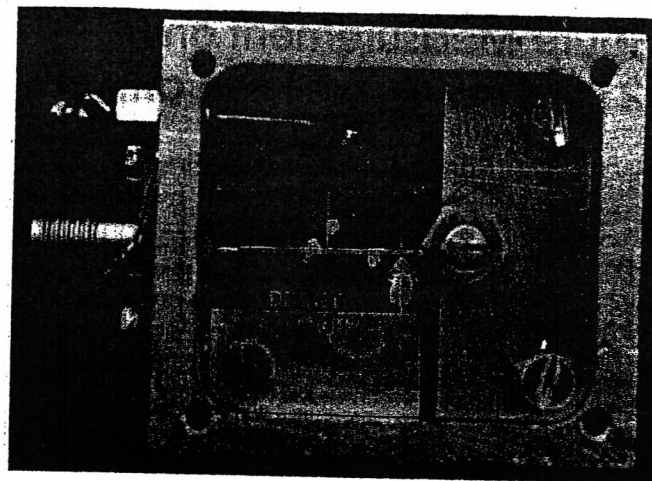
1. DB6NT: LO für 24 GHz und 47 GHz, DUBUS 4/1990
2. OE9PMI: 76 GHz Transverter, DUBUS 4/89
3. OE9PMI: Hi-Q Filter für mm-Bänder
4. Hewlett Packard: AN-992: "Beam Lead Attachment Methods"

Frequenzverdreifacher: 25,3->76 GHz

Der Frequenzverdreifacher arbeitet mit einer Varaktordiode im Beamleadgehäuse. Die Schaltung ist in einem kleinen Alugehäuse eingebaut, und besteht wesentlich aus einer Leiterplatte (RT/dupl. 5870 / 0,125 mm O) sowie einer im Gehäuse eingebrachten 2,6 mm Bohrung die einen Rundhohlleiter bildet.

Bei einer Ansteuerung von ca. 90 mW bei 25,3 GHz konnten mit der Varaktordiode A 92220-5 (GaAs) der Russischen Firma ELECS Ltd. 1,5 mW bei 76 GHz erreicht werden (R_A ca. 5 kOhm).

(Vertriebt in DL IMT GmbH, Heinrich Bauermannstr. 9 Stuttgart).



Bild/Figure 21: 76GHz Tripler

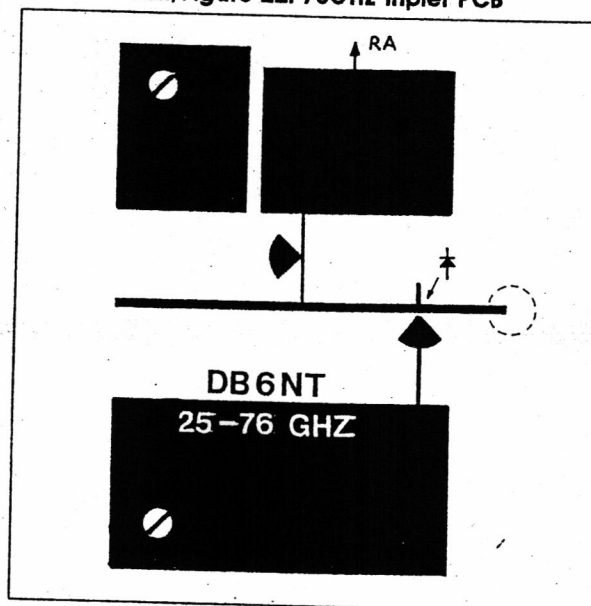
Anmerkungen:

1. Die Leiterplatte sollte mit Silberleitkleber und 4 M2 Schrauben in das Gehäuse montiert werden.
2. Aufbauhinweise in DUBUS 2.92 Seite 2...14 beachten.
3. Leiterplatten sind bei DB 6 NT- Gehäuse bei DG KBF erhältlich.

Abgleich:

Mit angeschlossenem Powermeter oder Indikator wird bei Ansteuerung von 25,3 GHz die Ausgangsleistung durch Abstimmen des Arbeitspunktes R_A sowie durch Anbringen von "Abstimmfädchen" optimiert. Dazu wird an geeigneter Stelle Silberleitlack aufgetragen und nach entsprechender Trockenzzeit durch Abkratzen auf max. Ausgangsleistung getrimmt. Mit dem Kurzschlußschieber (M3 Schraube) kann die Anpassung auf den Hohlleiter eingestellt werden.

Bild/Figure 22: 76GHz Tripler PCB



Tripler: 25,3->76 GHz

The tripler uses a varactor in beam-lead package. At a drive level of 90mW at 25.3GHz a russian GaAs-varactor A92220-5 from ELECS Ltd. produces 1.5mW at 76GHz with an R_A of 5kΩ.

Construction and Alignment

Fasten PCB with 4xM2 screws and some silver glue into box. Look for more hints in DUBUS 2/92, p. 2...14.

Connect powermeter and optimize for highest output power by changing R_A and adding tuning stubs which can be made by silver glue. Adjust shorting bar of the waveguide with the M3 screw.

76 GHz mixer for spectrum analysis

To have reliable means for tuning a mm-transverter, a spectrum analyser for the output frequency is required. This may not be part of the amateurs junk box. But if a standard analyzer up to 1.5 GHz is available a simple pre-mixer allows for spectrum analysis of the higher microwave frequencies (figure 1). A Gunn oscillator (MA or NEC) serves as a cheap LO for this mixer. With a 23 GHz LO the 24 GHz and 46 GHz bands can be observed: $24192 - 23000 = 1192$ MHz IF and $47088 - 2 \times 23000 = 1088$ MHz IF. For 76032 MHz a 25.0 GHz LO is required. That produces an IF of 1032 MHz.

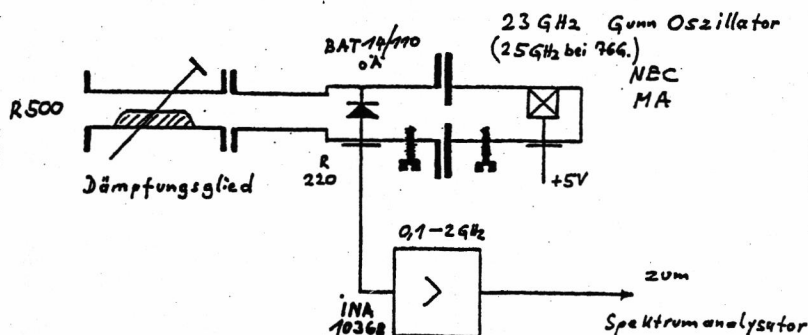


Figure 1 : SHF-premixer for spectrum analysis

Milimeterwellen Komponenten zu 76GHz Transceiver, 38GHz 80mW LO Amplifier, 38>76 GHz Verdoppler und 76GHz Mixer

Erich Zimmermann, HB 9 MIN CH - 4578 Bibern

Einleitung

Heutige 76GHz SSB Transceiver arbeiten mit Oberwellenmischer. Deren Rauschzahl liegt in der Grössenordnung von 20dB und die max. Ausgangsleistung bei -10dBm. Ein verbessertes Frontend ist zum Überbrücken von grösseren Distanzen oder bei Versuchen mit schlechten atmosphärischen Ausbreitungsbedingungen (zumeist an Kontests!) unerlässlich. Es werden Transceiverbaugruppen vorgestellt, die beim Senden und Empfang eine Verbesserung von ca. 10...15dB bringen.

Wegen technischen Problemen gelang es nicht den Mischer bis zum Drucktermin fertigzustellen. Er wird zu einem späteren Zeitpunkt in der DUBUS veröffentlicht.

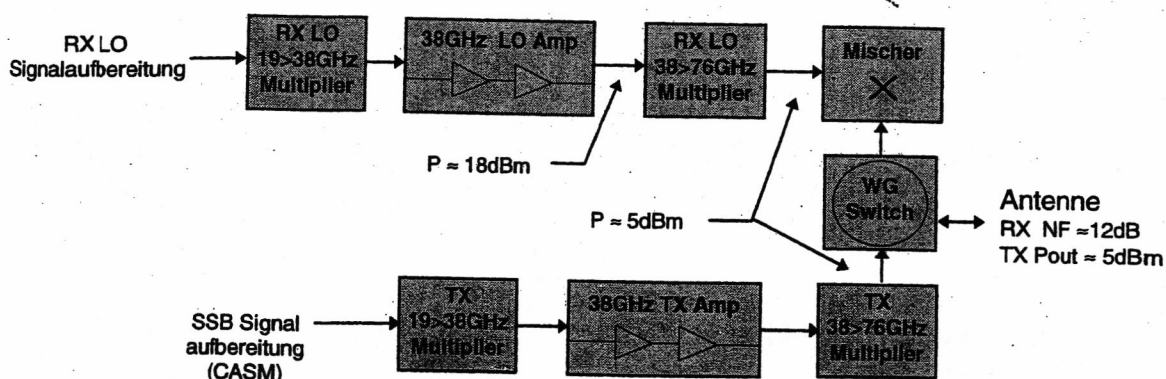


Bild 1: Einsatz der Komponenten im HB9MIN 76GHz SSB Transceiver

38GHz 19dBm LO Leistungsverstärker

Dieser Verstärker hat im ganzen Konzept eine entscheidende Bedeutung. Er ist notwendig um dem Verdoppler bzw. dem Mischer genügend LO Leistung zur Verfügung zu stellen. Die Rechnung ist einfach: Der 76GHz Mischer benötigt 5dBm LO Leistung, somit sind mit 12dB Verlust des 38/76GHz Verdopplers, bei 38GHz 17dBm Steuerleistung erforderlich.

Ein weiterer identischer Verstärker lässt sich zusammen mit den 38/76GHz Verdoppler im Sender einsetzen. Damit erhöht sich die Senderausgangsleistung von -5dBm (Sendermischer), auf ca. 5dBm (Senderverdoppler). Siehe auch Bild1.

Leistungen im Bereich von 100mW erbringen die heute erhältlichen MMIC's problemlos. Die rel. hohen Preise, minimale Bestellmengen, Verarbeitungsprobleme und Risiken verhindern deren Einsatz nicht nur im Amateurfunk. Deshalb wurde eine andere, günstigere Lösung gesucht, um mit käuflichen Halbleitern und ohne zugriff auf Chipverarbeitende Techniken oder Labors einen Verstärker zu realisieren: Zwei aus den Gehäusen ausgebaute PM- HEMT Chips, werden in eine diskrete Verstärkerschaltung auf RT-Duroid integriert. Das Resultat lässt sich sehen:

- Ausgangsleistung 80mW
- Verstärkung 10 dB bei 80mW Ausgangsleistung.
- 12dB Verstärkung im linearen Bereich.

Mehrere Verstärker sind aufgebaut worden und sie arbeiten zuverlässig und stabil.

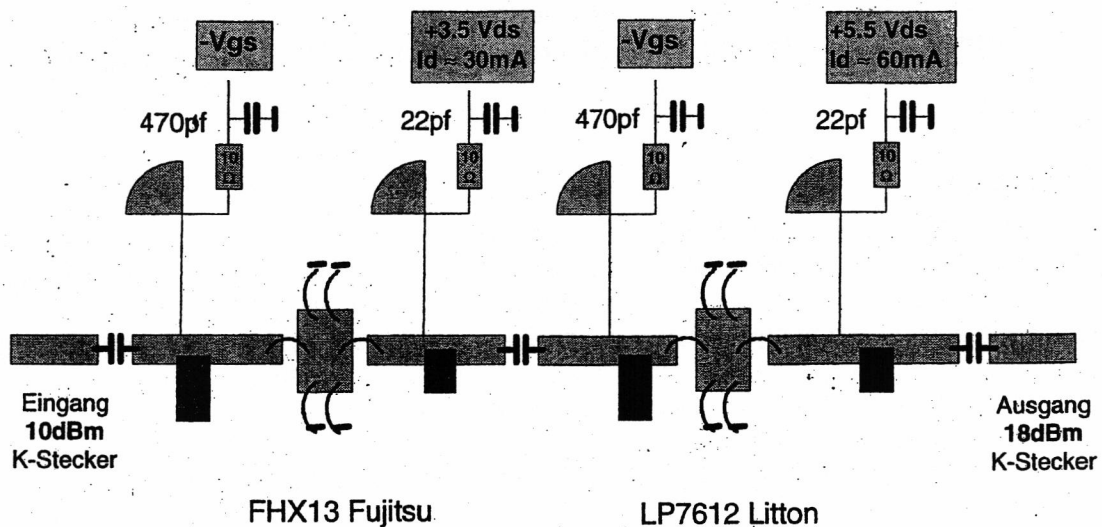


Bild 2: Schaltbild 38GHz PM-HEMT Verstärker.

Technical Data: 38GHz 2Stage Chip Amplifier		
PM-HEMT 1	FHX13 Fujitsu	Vds: 3.5V, Id: 90% Idss ≈ 30mA
PM-HEMT 1	LP7612 Litton	Vds: 3.5V, Id: 90% Idss ≈ 30mA
Linear Gain	F: 38GHz, Pin: 0dBm	typ. 12dB
Po sat	F: 38GHz	typ. 18dBm

Beschreibung, Konstruktionsdetails, Beschreibung der Arbeitsvorgänge

Der gesamte zweistufige Verstärker, inklusive Stromversorgung für Gate und Drain, ist auf einer 125um dicken RT-Duroid Leiterplatte aufgebaut. Dank den neusten, kleineren SMD Komponenten benötigt die Stromversorgung nur noch geringen Platz. Als Verbinder eignen sich die bis 40GHz spezifizierten K-Stecker.

Weitere Details zu diesem Verstärker werden in den DUBUS veröffentlicht.

Zusammenbau der Leiterplatte ins Gehäuse:

- Die mit den notwendigen Durchkontaktierungen versehene Leiterplatte wird mit EPO-TEK®H31D Leitleber, unter Anpressdruck, ins gefräste Messinggehäuse geklebt und während 45 Minuten bei 160° ausgehärtet.
- Danach werden alle SMD Bauteile bestückt.
- Die als Interface zwischen der Leiterplatte und dem K-Stecker dienen zwei kurze Stücke Dielektrikum mit Innenleiter aus EZ-47 Semiridkabel. Vorsichtig werden sie in die Bohrung (Ø 0.97mm) der Gehäusewand eingeführt und mit der 50Ω Streifenleitung verlötet.
- Nach Abschluss aller Lötarbeiten wird die Stromversorgung überprüft.
- Nun werden mit einem Skalapell die 0.5 x 1mm grossen Schlitz für die Chips hergestellt. Mit Verdünner wird der Verstärker gründlich gereinigt und mit Pressluft ausgeblasen.

Demontage der Chips:

- FET Gehäuse auf ca. 250°C aufheizen und vorsichtig den Gehäusedeckel entfernen
- Mit Präpariernadel alle Bonddrähte von den Bondstellen des Gehäuse lösen. Dies muss mit äusserster Sorgfalt geschehen!
- FET Gehäuse auf ca. 250°C aufheizen, mit flach zugespitzter Nadel, Chip vom Gehäuseboden lösen.
- Chip mit Zahnstocher von Gehäuse entfernen und in reinem Alkohol reinigen.

Montage der Chips

- Im Zentrum der Aussparung, an der Stelle wo die FET's eingeklebt werden, ein kleiner Tropfen EPO-TEK H31D aufbringen. FET Chip plazieren (zB. mit Zahnstocher) und leicht andrücken. Derselbe Arbeitsgang für den zweiten FET. Aushärten des Klebers bei 160° während 50 Minuten.
- An den Klebestellen der Gate-, Drain- und Source Bonddrähte kleine Tropfen EPO-TEK H31D aufbringen
- Bonddrähte an die Klebestellen andrücken. Die Bonddrähte müssen an den Klebestellen mit Leitkleber bedeckt sein, ggf. einen Tropfen Kleber zugeben. Besonders die Source Bonddrähte sind möglichst kurz an Masse zu legen. Aushärten des Klebers bei 160° während 50 Minuten.
- K-Stecker montieren. (Vorsicht: Das mit den K-Steckern versehene Verstärkergehäuse darf nicht mehr erwärmt werden, dies führt zu dessen Zerstörung!!)

Inbetriebnahme und Abgleich

- Speisespannung anschliessen und Drainströme der FET's über den 10 Ω Widerständen messen.
- Powermeter anschliessen, Verstärker mit ca. 8dBm ansteuern. Abgleichen durch optimieren von Position und Länge der Stubs. Sie sind nach erfolgtem Abgleich äusserst vorsichtig mit geringsten Mengen Lötzinn (Niedertemperatur Lot) anzulöten. Der Stub am Ausgang dh. am Drain der LP7612 ist erst nach dem Zusammenbau mit dem 38/76GHz Verdoppler auf maximale Ausgangsleistung zu optimieren und erst dann anzulöten.

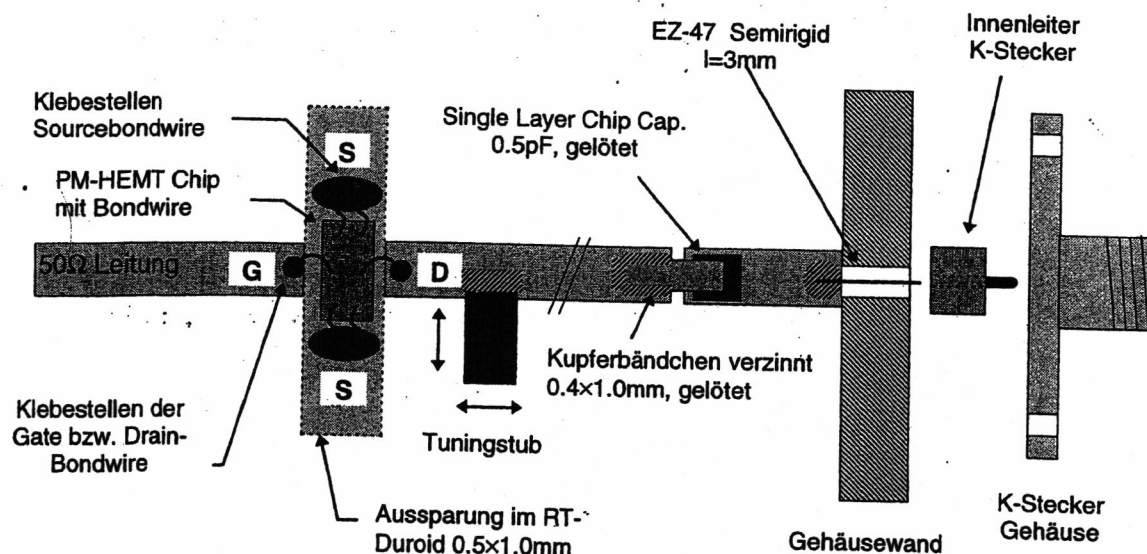


Bild 3: Konstruktionsdetail 38GHz Chipverstärker

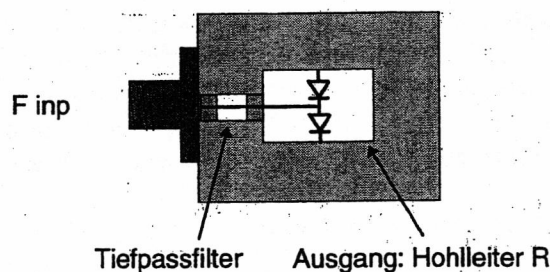
38 auf 76GHz Verdoppler mit 5dBm Ausgangsleistung

Um für den Mischer 5mW LO Leistung zu erzeugen, stehen verschiedene Verdoppler Typen zur Verfügung, die alle ihre Vor- und Nachteile haben:

- PM-HEMT Verdoppler: nur mit MMIC möglich. Geringer Umsetzverlust ca. 4dB,
- Varaktorvervielfacher: geringer Umsetzverlust ca. 8dB, bei nicht optimalem Arbeitspunkt instabil und Rauschen
- Diodenverdoppler: einfach, unkritisch, preisgünstig, Umsetzverlust ca. 12dB

Für Funkamateure ist der Diodenverdoppler nach C.P. Hu von Honeywell, trotz der höheren Umsetzverluste, am besten geeignet. Als aktive Elemente dienen zwei handelsübliche und preisgünstige GaAs Beamlead Dioden (HSC9101). Die prinzipielle Anordnung des Verdopplers ist in Bild 4 ersichtlich. Das Eingangssignal gelangt über den K-Stecker, dem Tiefpassfilter zu den Dioden. In dieser Anordnung der Dioden werden die ungeraden Oberwellen unterdrückt und die geraden über den Hohlleiter ausgekoppelt.

Bild 4:
Millimeterwellen Verdoppler
nach C.P. Hu von Honeywell



Technical Data: 38 / 76 GHz Doubler		
Output Power	5dBm	Pin 17dBm at 38GHz
Conversion loss	typ. 12dB	Po 5dBm
max. Input Power	150mW	

Beschreibung, Konstruktions Details, Abgleich

Angestrebt wurde ein möglichst einfacher Aufbau. Dies lies sich trotz mehreren Versuchsaufbauten, aus elektrischen oder konstruktiven Gründen nicht realisieren. Wir bewegen uns hier in der Millimeterwellen Technik, dh. für ein gutes Produkt ist ein gewisser Aufwand unerlässlich. Kommerzielle Produkte sind nicht sinnlos in gefrästen und vergoldeten Gehäusen untergebracht!

Der Einsatz von mechanisch empfindlichen Beamlead Dioden im Hohlleiter erfordert einen stabilen Aufbau. Um die sie in den Hohlleiter einbauen zu können, besteht der Verdoppler aus zwei zusammenschraubbaren Teilen, einem Kurzschlusschieber- und einem Multiplizierblock.

Damit die Verluste möglichst gering sind, wird der Verdoppler mit dem K-Stecker direkt auf den 38GHz Verstärker geschraubt. Das Tiefpassfilter, es verhindert das Abfließen der Oberwellen in Richtung Stecker und ermöglicht auch das Anpassen der Dioden. Zur Vereinfachung wurde auf dieses Tiefpassfilter verzichtet. An dieser Stelle tritt eine 50Ω Leitung aus einem EZ47 Semirigid Kabel. Das Bauteil mit dem Innenleiter (im Bild unten rechts) wird seitlich eingepresst. Danach kann das Dielektrikum, von der anderen Seite her, darüber geschoben werden.

Die in der Breitseite des Hohlleiters eingepressten Diodenhalter ermöglichen eine zuverlässige und reproduzierbare Kontaktierung der Beamlead Dioden an den Hohlleiter Innenseiten.

Nach Abschluss dieser Arbeiten wird der Mischerblock mit Alkohol gereinigt. Als nächster Schritt sind die beiden Dioden mit der richtigen Polarität mit EPO-TEK H31D einzukleben und während 50Min bei 160°C auszuhärten. Zuletzt wird der K-Stecker montiert und der Multiplier- mit dem Kurzschlusschieber Block verschraubt.

Beim Abgleich wird wie folgt vorgegangen:

Spektrumanalyzer oder und Leistungsmesser am Ausgang anschliessen, Verdoppler mit 38GHz Verstärker ansteuern.

Kurzschlusschieber und Ausgangsanpassung des Treiberverstärkers wechselseitig auf maximale Ausgangsleistung optimieren. Erzielt man 5dBm Ausgangsleistung bei 18dBm Steuerleistung arbeitet der Verdoppler optimal.

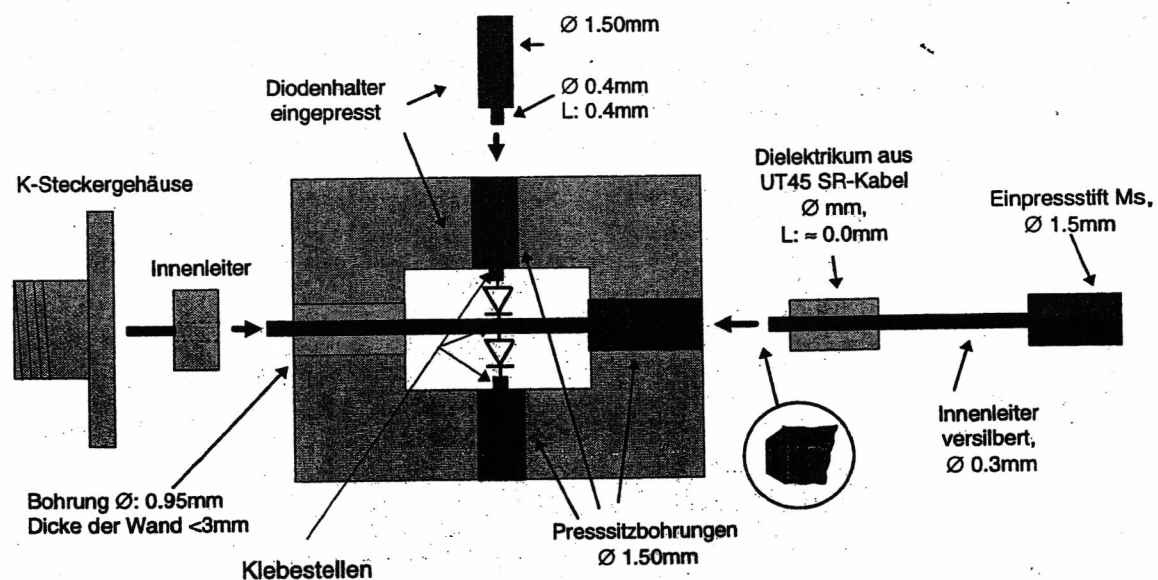


Bild 5a: Konstruktionsskizze des 38/76 GHz Verdopplers, Schnitt A-A.

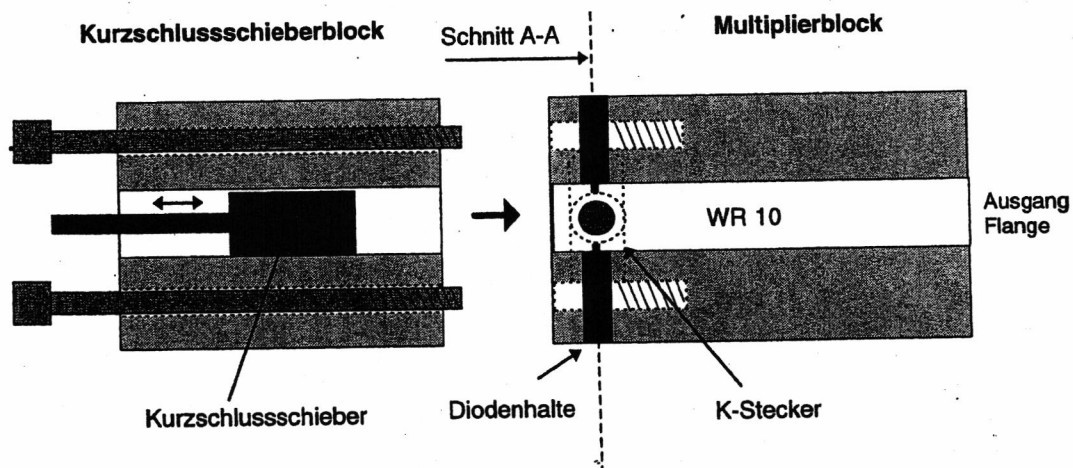


Bild 5b: Konstruktionsskizze des 38/76 GHz Verdopplers, Seitenansicht.

Mischer

Als erstes wurde ein „Durchblasemischer“ mit einer Beamlead Diode aufgebaut. Wegen den vermutlich zu hohen Zuleitungsinduktivitäten im Hohlleiter, flossen trotz 5dBm LO Leistung maximal einige μA Diodenstrom. Mit einem eingeprägten Ruhestrom von 500uA verringerte sich der Mischverlust beträchtlich und war ca. 3dB tiefer als bei einem kommerziellen Oberwellenmischer. Als Sendermischer ist seine Ausgangsleistung zu gering.

Diese Typ von Mischer wird nicht weiter verfolgt. Es ist das Ziel einen mit zwei Dioden arbeitenden Gegentaktmischer zu realisieren.

Auf Grund der vielfältig zu lösenden techn. Probleme liess sich dieser Mischer nicht bis zum Manuskript Termin realisieren. Er wird zu einem späteren Zeitpunkt in der DUBUS veröffentlicht.

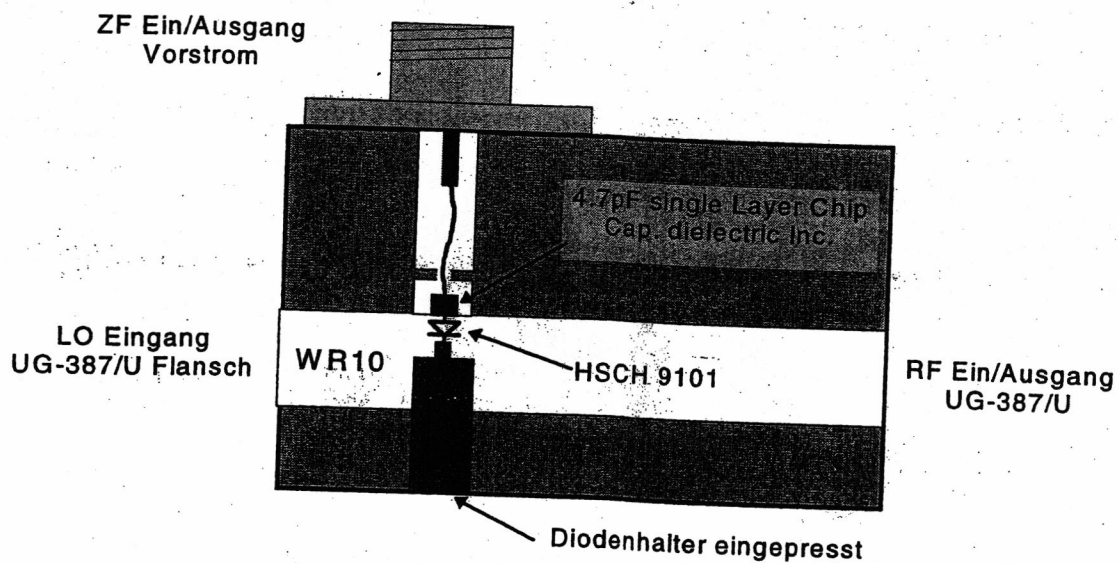


Bild 6: Versuchsaufbau „Durchblasemischer“

The G8ACE Transverter for 76GHz

By John Hazell, G8ACE

A detailed résumé of the talk at RAL, April 2000

The 76 GHz Transverter can be divided into three building blocks:

- 1 The local oscillator up to a frequency of 9.5 GHz.
- 2 A means of controlling oscillator stability and frequency predictability.
- 3 The transverter using the DB6NT design.

The finished project then must be tested for frequency compliance.

The local oscillator up to 9.5 GHz:

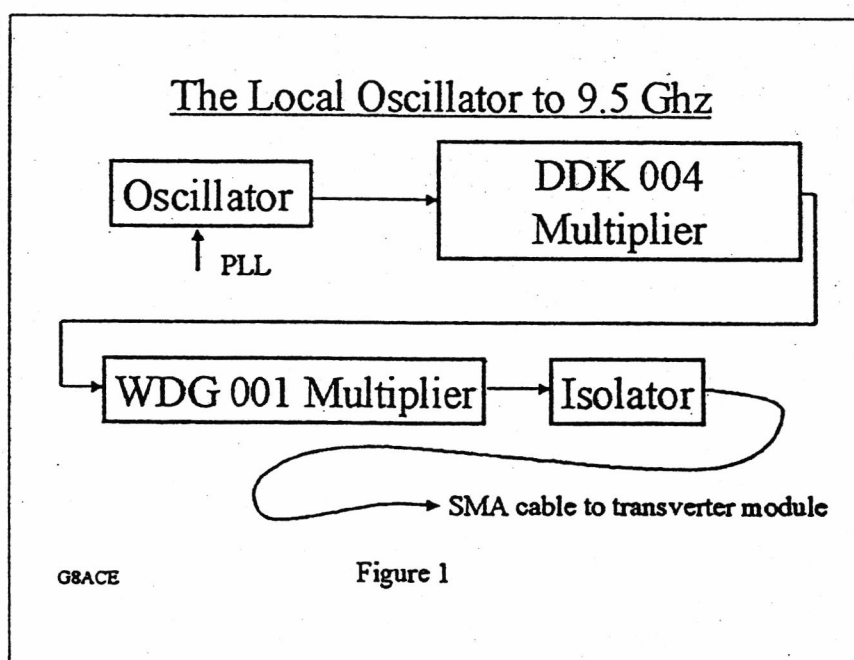


Figure 1. shows the local oscillator blocks. There's nothing new here. Microwavers will be familiar with these circuits and it is typical of a 10 GHz LO system, albeit with a re-tune to 9.5 GHz. In detail, the well known DDK004 board is used but in my construction the transistors used are 2 x BFS17 and 3 x BFR92. The output tuned circuit at 2.4 GHz is slightly modified to use available tubular trimmers at the expense of slightly worse harmonic content, -40db, but the increased output power of 25mW allows for a simplified WDG001 board. The crystal is not used in the DDK004 board and the input

drive is coupled to the first emitter via 100pF and the second transistor emitter is bypassed with 1000pF instead of 22pF. With the transistors used, plenty of signal is available at each stage. Apart from the first stage which already has a damping resistor across its tuned circuit and the last transistor, 10R is included in series with each transistor collector to help with the nasty side effects of the transistors bottoming with large amplitude signals.

The WDG001 board is simplified to use 3 GaAsFETs only, no MMIC. With 25mW available drive, the MMIC is replaced with a 3dB pad.

My own measurements suggest the multiplier stage (I use the Birkett surplus types here) requires an input of around 5mW to achieve satisfactory output for the following stages using the NEC NE325 GaAsFET. A long flexible cable is used to connect the 9.5 GHz LO signal output to the transverter in the dish, so an sma isolator is used at the output of WDG001. 40mW drive is available at this point.

The oscillator itself employs a modified **DF9LN OCXO** module. The modifications were to add a second, isolated output to supply the phase lock loop and varicap tuning for frequency control. The proportional oven used to heat the crystal and oscillator circuit was also modified to use a readily available and inexpensive NTC Thermistor from Farnell instead of a PTC type. This requires the interchange of two components. The small thermistor was passed through a hole in

the heater plate for good thermal contact with the heater transistor bolted to it.

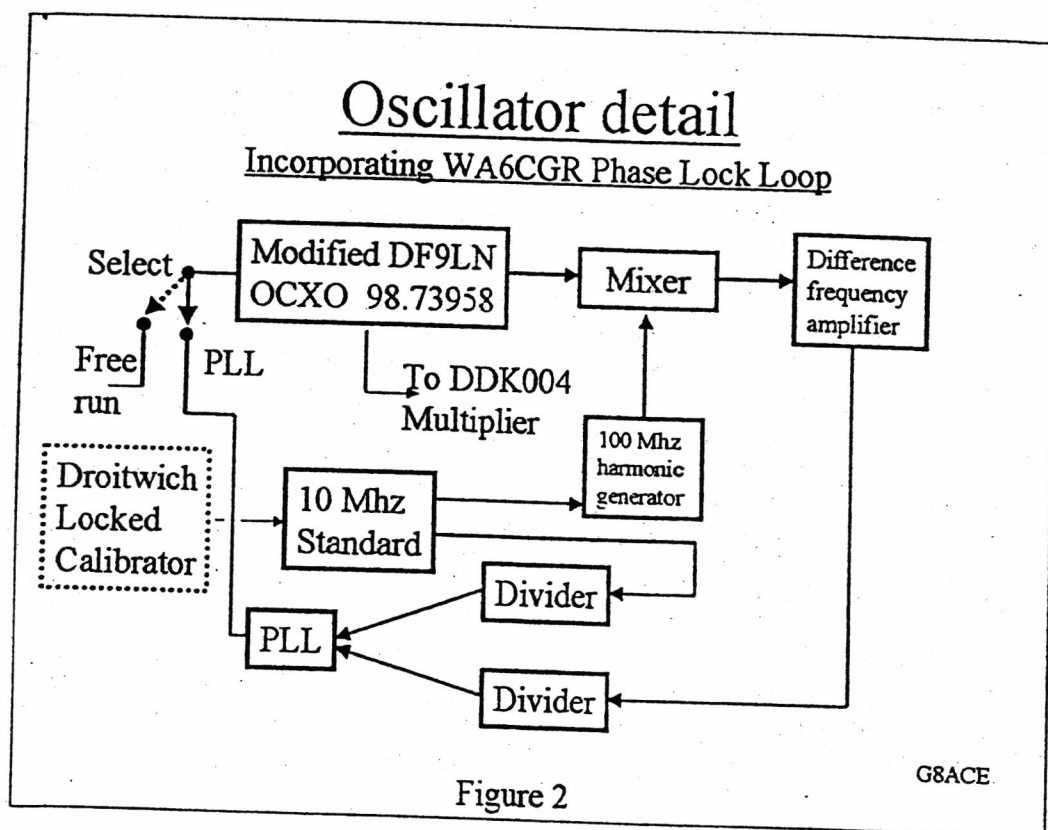
There are two points to consider with the oscillator. First, the coupling of the varicaps.... this should be as light as possible whilst enabling adequate control range since any noise on the control line will impair the quality of the signal. Higher stability in the oscillator will enable lighter control. Measured at 76GHz, the pull range of the LO is 160 kHz, a compromise between lock time at switch on and signal quality. The PLL can be disconnected from the oscillator and the varicap control volts are then taken from across a red LED used as a shunt regulator.

A further point to note when testing the module is that if a low temperature is used, ie 40°C, the dissipation of the circuitry may exceed the heating control setting and the frequency will continue to drift.

The Phase Lock Loop (PLL)

The PLL is no substitute for a less than stable oscillator but it does bring useful benefits. Its inclusion was to aid testing for operation within the UK allocation. The rf output of the transverter compliance must therefore be done in receive mode. Use is made of the **WA6CGR PLL system** known to microwavers for its benefits in 10GHz operation. The block diagram of the scheme used is shown in **figure 2** below.

A frequency standard is a necessary prerequisite of the PLL for stability and accuracy. For portable operation, I use a Racal 5MHz 12v unit obtained at a Microwave Round Table. Warm up is quite rapid and a reasonable performance is obtained after ten minutes when compared to my Droitwich locked calibrator.

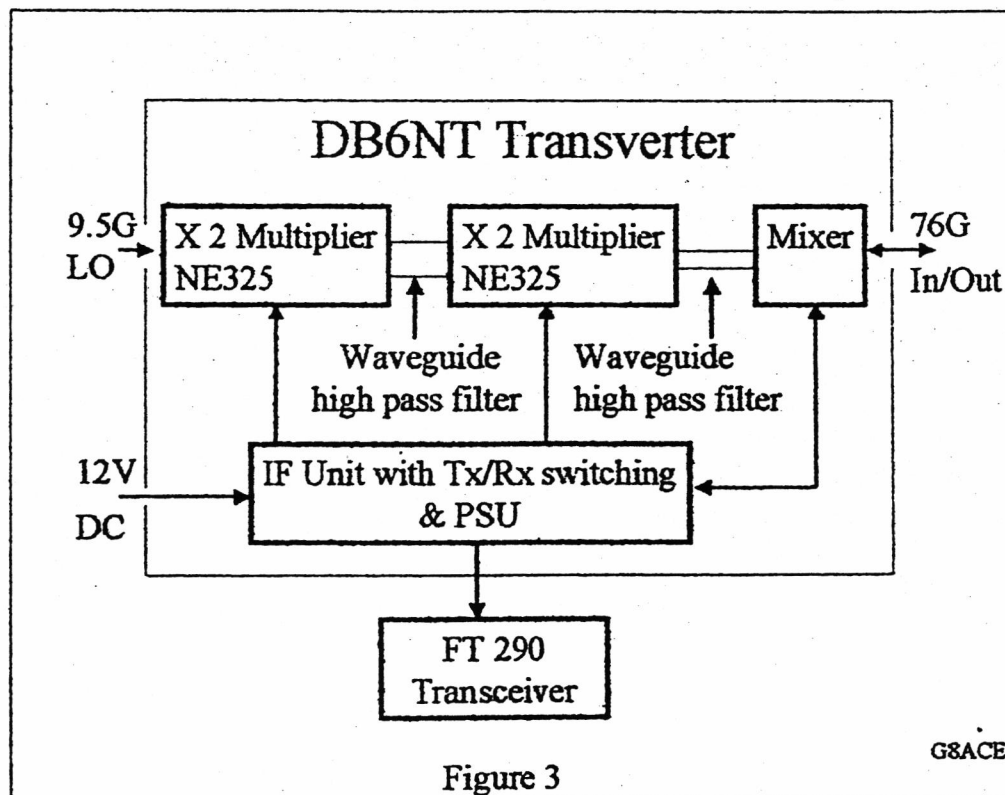


A diode push -push doubler, together with a CMOS 74HC04, provides 10MHz outputs. The benefit of 10MHz over 5 MHz is that I can directly substitute other 10MHz sources including the Droitwich locked reference. It also eases the 10th harmonic production necessary in the PLL. A TCXO used in Cell Phones can be employed instead as the reference. This will still give worthwhile other than 10MHz are often found and calibration will be more difficult with these. A Basic programme, to be found with other information at the WA6CGR website, allows for correctly programming the frequency dividers used in the PLL. Points to watch are: select your crystal for a

multiplication ratio to 76GHz, which does not result in a very low comparison frequency in the PLL. Also the programme allows for near correct frequency operation and, again, this offset error, if any, can be minimised by optimum crystal frequency selection. The original PLL circuit uses 74162 ICs for dividing and these are now hard to obtain. Whilst they allow easy decimal programming, the readily available 74163 can be used but just use binary programming instead. The divider counts in my unit can be modified by diode switching for operation on 76032MHz, used in initial testing, and 75976MHz, the preferred UK narrow band segment. The LO. crystal must be changed of course.

The DB6NT Transverter

The design and construction notes for the Transverter are to be found in Dubus.



It is not necessary therefore to detail the construction but just to mention design changes. The unit contains two doubler PCBs, one from 9.5GHz to 19GHz and the second from 19GHz to 38 GHz. The NEC transistor was used throughout. This is different to the devices specified. It is entirely adequate for the first doubler where no tabbing adjustments were

required for adequate output power to drive the second doubler via the high pass waveguide filter. In fact the first doubler operates to well under 1mW of drive, so a lossy cable to carry the 9.5GHz signal from the main LO. is of little consequence.

To obtain 38GHz at enough power for the Anti-Parallel Mixer is a challenge. The anti-parallel mixer has the advantage that it requires drive at one half the LO frequency so packaged GaAsFETs can just about work here. The mixer diode requires around 5mW to start it switching and little more than this is achievable from the NE325. Constructors are therefore recommended to use the specified device for this doubler. Typically, from my measurements on 24 and 47GHz, the rf output is -20db or more on the amount of LO applied to the mixer. The DSB output power measured at R.A.L was in the region 40-50mW. More LO power should hopefully improve the output signal to the levels achievable at 47GHz an area for further development.

A 2m IF is used for simplicity and the circuitry chosen is that used by DB6NT for his 24GHz MKIII Transverter, the only changes being to substitute a BFG67 IF transistor and HP PIN diodes, these being readily available from Farnell. Additionally, an LM317 Regulator is incorporated, utilising the PIN switching control volts to set the local oscillator drives applicable for best Tx and Rx performance.

Testing for operation on the correct frequency

The lower frequency part of the LO. chain can be checked in the usual ways a frequency meter at the crystal frequency, wavemeters, etc, at the higher multiplication stages, depending how your shack is equipped. There should not be a problem at the higher end of the multiplication chain (crystal x 768) but if there was an error its effect would not be insignificant. The UK preferred narrow band segment is 75976MHz which does not relate to anything useful in frequency from the lower bands.

At the outset, it was decided to use a crystal for 76032MHz, the European segment, which relates directly to a harmonic of 115 MHz in the old tradition. 1152 sources usually employ 96MHz crystals and my existing unit was already phased locked to provide a harmonic at 10368.101MHz, the nearest the WA6GCR PLL division ratios would allow me to get to 10,368.100

As the 76GHz band is 7.3 times the 10GHz band, a harmonic could be calculated to exist on 76032.740MHz. With the LO and the source locked by the PLLs, a signal was found (with relief!) at 76032.740MHz. At the Sandown Convention, a 9.5GHz multiplier block was found that would fit an existing Ferranti brick oscillator. Harmonics were produced from this brick using a G3PYB diode generator previously described in the Microwave Newsletter. This enabled signals to be generated from the calibrated Adret, this time using a base frequency of 105.5225 MHz multiplied by 720 to reach 75976.200MHz. The LO crystal was changed and the signal found immediately. By changing the Adret in 10Hz steps the received frequency was found to move in 7.2kHz steps. With the first test on 76032 and now this one, it seemed fairly conclusive that operation in the 76GHz band had been achieved. Measurement at RAL 2000 verified this. G8BKE has constructed his system using the TXCO reference option in his PLL which, in my own tests, showed a frequency repeatability of between 10 and 20 KHz between operating sessions. During our compatibility tests we found our signals were just 15kHz apart on this band as we prepared for a first QSO.

References:

G4DDK 004 Source	Microwave Handbook Vol. 2 page 8.13
G3WDG001 Multiplier	Microwave Handbook Vol. 3 page 18.101
DF9LN OCXO	Dubus 3/97.
WA6CGR PLL	www.ham-radio.com/wa6cgr/mwpll.htm
DB6NT 76GHz Transverter	Dubus Technik IV Page 366
G8ACE website	www.microwaves.mcmail.com/

(Editor's note: Our thanks to John for this and the following article on 76GHz. We hope it encourages others to have a go!)

FREQUENCY JITTER PROBLEMS AT 76GHZ -

~ by John Hazell, G8ACE

Editor's note: The problems described below have been experienced by a number of UK operators using UK manufactured crystals in the well-known G4DDK004 local oscillator. Permanent cures have been effected by ordering new crystals from Eisch Elektronik in Germany.

Two crystals were ordered together for my 76GHz project, one for 76032 the other for 75976. Both suffered extreme "jitter", i.e a very unstable note. What I then had to do was establish whether the source I was listening to was the culprit or whether it was the LO or both. What made matters worse was that I had PLL circuits attached to all and so I confused myself initially thinking these were causing the problem, the PLL showing also some coherent jitter. So it was the same old story! Was it the cause or just the result of the jittery crystal. In fact it was neither and now seems of little consequence as it's still there with the problem fixed.

The turning point was finding a varactor multiplier block for 9.5GHz at Sandown. Attaching this to an existing multiplier-less brick, allowed me to use the Adret as a source on 76GHz. This eliminated the original source I was listening too and it was just the same note now with the Adret.

Not soon enough, I eventually tried the crystal free running and sure enough I still had jitter. I tried several circuits to be certain but all were the same. I suffer from the problem that, when there is a problem, it must be my fault! So having exhausted tests and also by this time having used G3PYB's 9.5GHz oscillator on my transverter to listen to the Adret, with perfect results, it was time to confront Quartslab. They of course said their crystals did not suffer this sort of problem. However I wrote a long explanation of what I had found and returned both crystals. First, they sent one back for me to check. As far as I can tell they heat the leadout wires close to the crystal can for 10-15 seconds with a soldering iron. This takes the stresses out of the connection wires to the crystal. Clearly they do know about this problem and how to fix it. What they do not have is test equipment which will allow them to see it.

So if anyone out there has a crystal that jitters, a bubbly note, which is clearly going to be worse the more it is multiplied then send it back with a note about the problem. Microphony they do know about but that's a different effect. What is interesting is that I was just unlucky! The 105.5225MHz crystal driving the brick source at the end of the demo bench during my talk at RAL 2000, instead of the Adret, is untreated and does not seem to suffer the problem. It seems the problem is purely random. I ordered the 105MHz crystal before I realised it was the supplier's problem and it had been despatched before I could contact them. They confirmed afterwards it had not been treated.

Higher band activity report for Finland and Japan

Michael Fletcher, OH2AUE

Some microwave history from Finland

Considering the population of Finland (approx. 5.5 million) and the amount of ham radio operators we have, there is quite a lot of microwave activity on the bands. During the seventies there was a little activity on 2.3 GHz using converters and multipliers, but the first band to really take off was 10 GHz. This was due to the G3JVL transverter design published in the RSGB Radio Communication magazine.

This design by Mike Walters was reproduced and also modified to suit local conditions on 10368 and many nice QSO's were made using this bilateral converter. The typical outputs were in the order of 1 mW and the noise figures around 9 - 10 dB. IF's were on 21 MHz, 144 MHz and 432 MHz during various experiments. There is a clear analogy here to the current experiments on 47 and 76 GHz. The G3JVL transverter was replaced with various commercial (active) transverters and ham designs over the years to come. The higher outputs and lower noise figures led to longer distance QSO's and also allowed new propagation modes to be used, like rain scatter and tropospheric scatter.

Earlier on, these modes were only possible by using the G3JVL to drive a TWT. These amplifiers were very scarce in the eighties and very few hams had an opportunity to experiment with powers in the 10 W range. During some of my own experiments almost 20 years ago we made some very interesting one way QSO's over different non line of sight paths and double and triple reflections off masts and other obstacles.



QRV: OH2AUE with homebrew 76 GHz transverter and JA1AT1 antenna

Finnish hams gain access to 3.4 GHz

Since those times a lot of development has taken place and even new bands have been opened to Finnish hams, like the 3.4 GHz band. We actually lost the narrow band section of the 10 GHz band for a few years, but due to our active Finnish Radio Amateur League (SRAL), this was made available again a few years back. The 3.4 GHz band is probably the quietest band with only two stations active in Finland. This is sad as there is an abundant amount of 4 GHz band hardware available even on the Finnish market: microwave radio equipment, TWT's, waveguide, parabolic dishes etc. Even commercial C band (reception) hardware is easily modifiable to 3.4 GHz. There has been some C band (uplink) equipment available from Russia over the years and this should have increased the 5.7 GHz activity, but even then we only have about four stations active on this band.

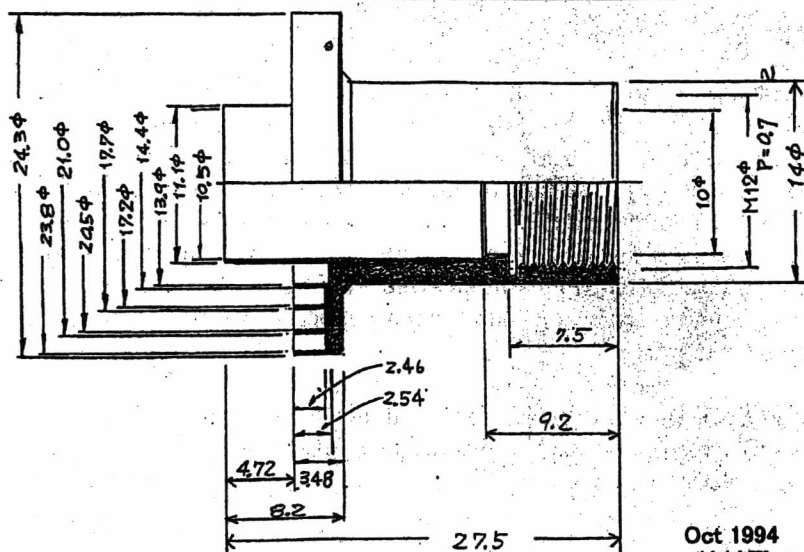
2.3 GHz band surplus

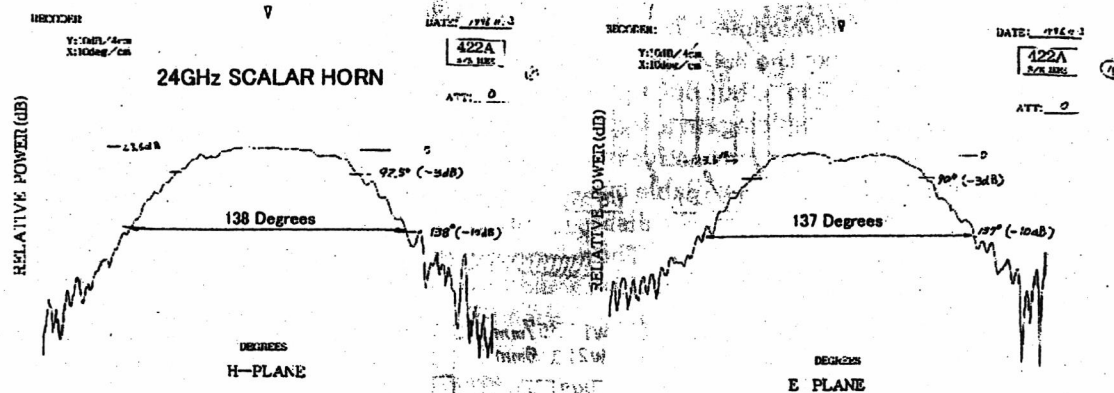
The commercial availability of 1.3 GHz transverters and rigs has made this a popular band after 144 and 432 MHz and is often a stepping stone for the higher bands. For 2.3 GHz there is a lot of surplus microwave radio equipment available that can be modified into decent transverters or at least parts thereof, like preamplifiers and power amplifiers. My own 2.3 GHz transverter covers 2304/2320/2400/2446 MHz with both 144 and 432 MHz IP's at the flick of a switch. This rig is based entirely on a surplus radio. The controller is made by a friend of mine and is built around a teletext PCB using the 8031 processor. Switchable filters are needed for image and LO rejection though.

24 GHz and 47 GHz activity perking up

24 GHz has seen a boost in activity too: there are currently about five stations active on this band, most are running bare bilateral mixers of the DB6NT design with a subharmonic mixer. For a real challenge on 24 GHz, try picking the AO-40 satellite on 24048 MHz later on when it is QRV!

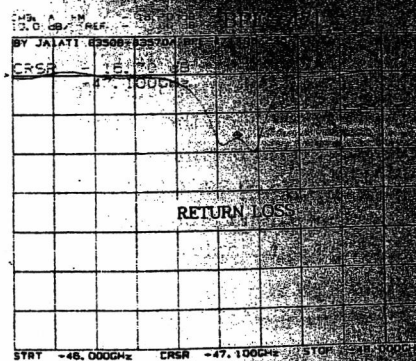
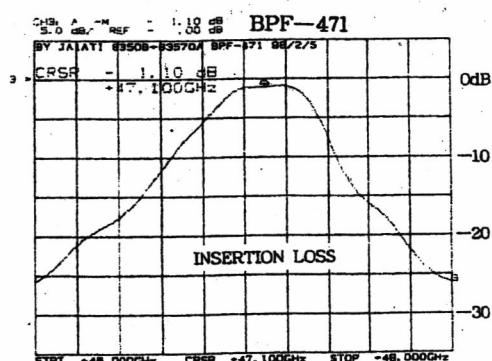
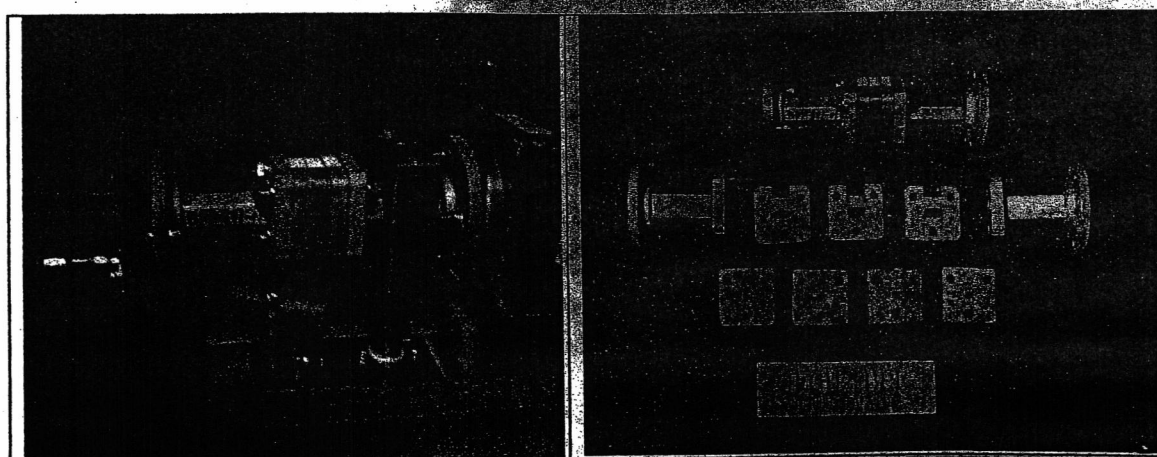
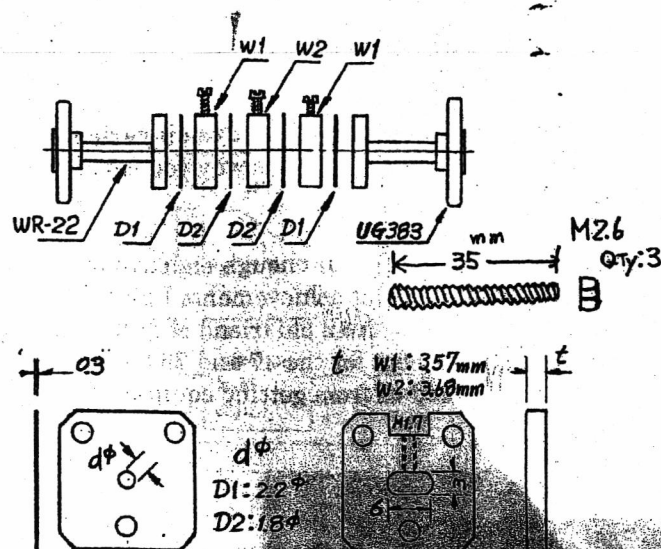
24GHz SCALAR HORN





Recently many stations have been upgrading to 300 mW an 700 mW with some commercially available high gain amplifiers. Also LNA's have been implemented dropping the noise figure to somewhere between 2 and 3 dB. The availability of 23 GHz band microwave radio surplus has also aided activity as the filters are retunable to our 24 GHz band by either omitting the filter cavity screws and force-tuning the filter to our band with only the coupling screws (!) or by simply denting the cavities on the narrow waveguide size to increase the resonant frequency. The surplus Gunn oscillators, that also easily tune to cover our 24 GHz band, can be swept via their varactors so as to form a simple sweeper. This, accompanied with a directional coupler, or even just a circulator, can form an effective analyser using a diode detector and oscilloscope for display.

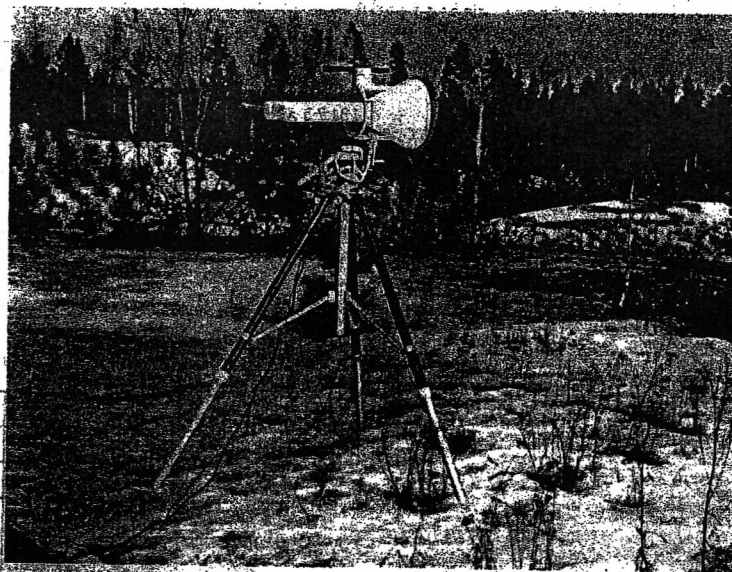
In Finland, it is already possible to generate a pileup at 24 and 47 GHz :-)
For 47 GHz, JA1ATI has developed an excellent bandpass filter. See drawings for more details.



47 & 76 GHz

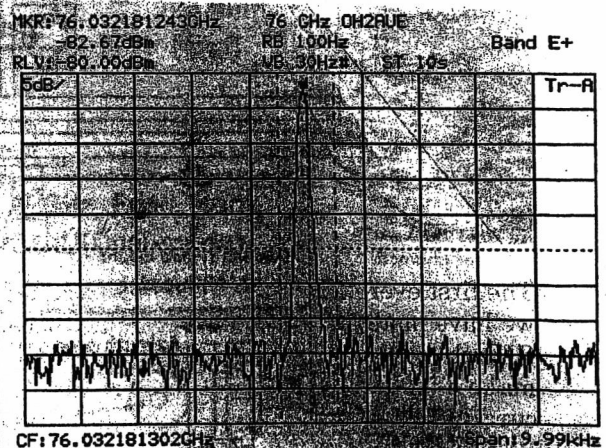
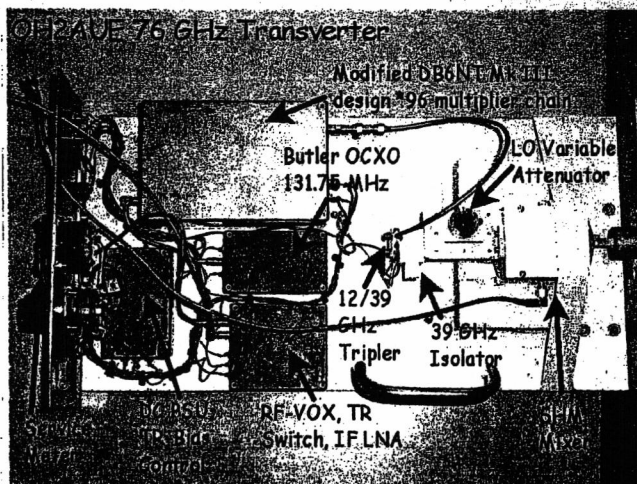
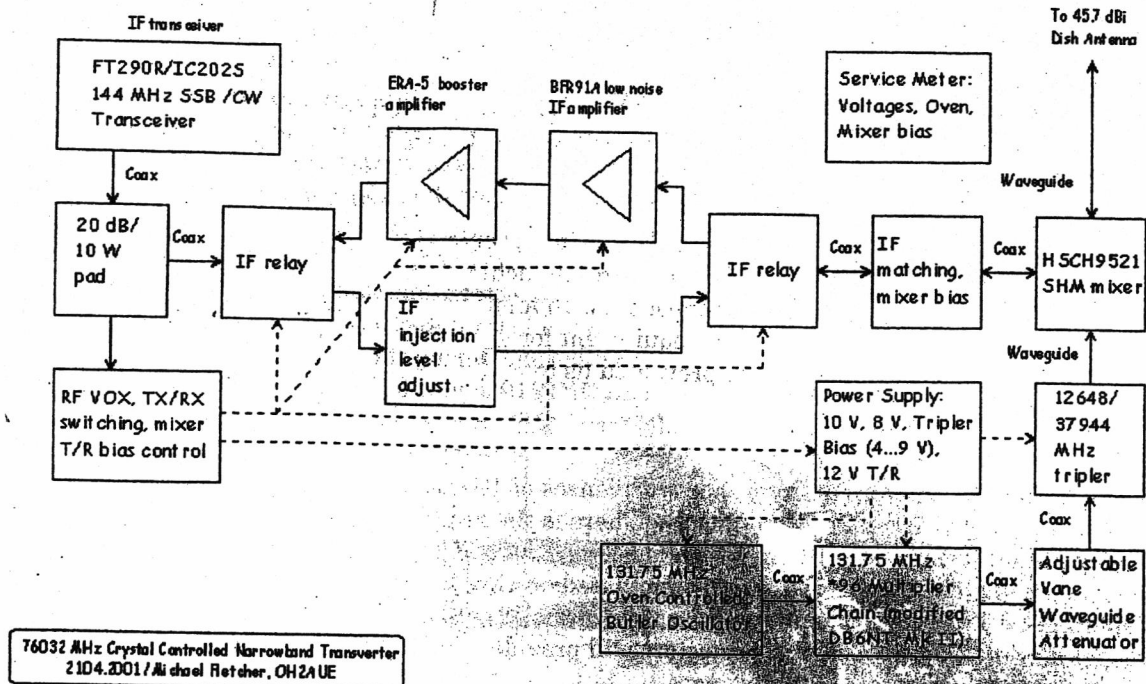
An interesting feature of getting started on a new band is that you invariably seriously consider building two radios for the band in question. In this way you can always ensure that you can make a QSO on that band too !

It is quite difficult to find a fellow ham that has similar enough endeavours to build equipment with simultaneously. For my most recent achievements I have been fortunate to be able to construct equipment simultaneously with an old friend of mine, OH1KHH. During last autumn and winter we constructed equipment for the 47 and 76 GHz bands. We live about 100 km apart, but this has not prevented us from getting equipment constructed, aligned and going QRV.



• OH2AUE and his portable 47 GHz transverter

The first ever 47 and 76 GHz ham band QSO's in Finland were held this spring. On 47 GHz we have made a 10 km QSO on SSB with excellent signals over a line of sight path and on 76 GHz thus far only a "calibration" QSO of 1 km. The system parameters for 47 GHz should make a 50 km QSO possible on CW. On 76 GHz we should be able to do the same with our current hardware and the antennas I have.



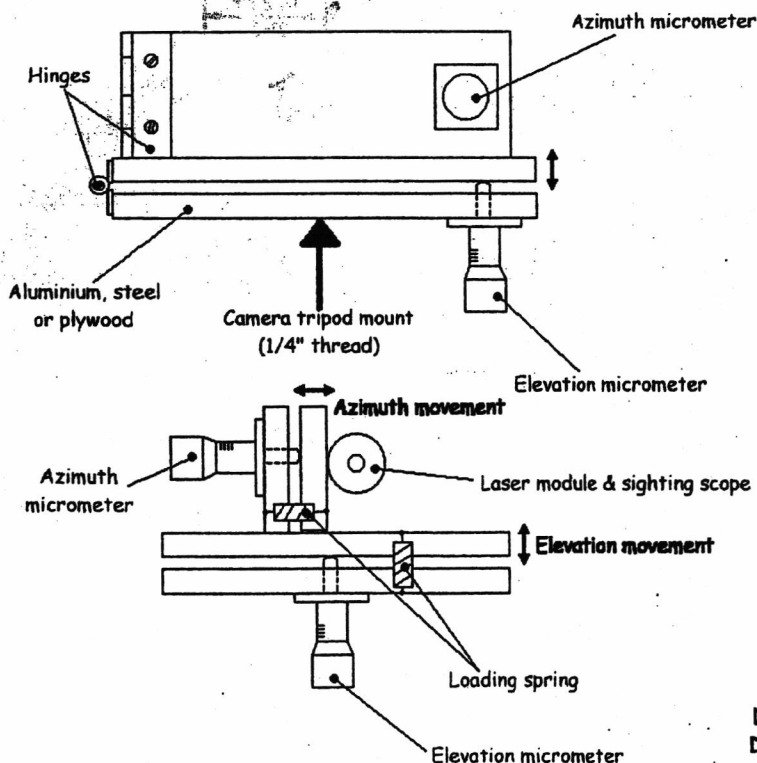
On the Finnish surplus market there is very little hardware for the millimetre and submillimetre wave bands though and components for the actual business ends need to be either manufactured yourself or searched for from the surplus markets elsewhere in the world (UK, US, Germany mostly). The 47 and 76 GHz mixers for our rigs had to be made ourselves for example. It certainly helps to know someone in the machining business. The serious millimetre waver would ideally have a small milling machine, a small lathe and also a stereo microscope. These are all big investments even if these instruments are found as second hand or surplus, but boy, would life be easier if you had them right there, in the corner of your shack !

Laser Comms

It is also worth noting that there is rapidly growing interest in optical communications. Most activity is around modifying laser diode devices (laser pointers, laser EAN code readers etc.) to have modulators allowing CW and even AM. Using AM modulation makes the use of SSB and other linear modes possible via the AM modulation. For detection, only an optical detector and VLF receiver is needed. K3PGP has done a lot of work with this type of modulation and his designs are often the starting point for the laser communication enthusiast.

Actual detector devices vary, usually being silicon detectors, but also photo multiplier tubes are being used. These detectors would also be suitable for detecting the AO-40 satellite infrared laser that carries 400 bit/s BPSK modulation. During the AO-40 launch campaign tests in French Guiana last Autumn I used an OPT210 device for copying perfect telemetry from the 834 nm IR laser on the spacecraft.

Typically optical detectors are preceded with lenses of 10 - 20 cm diameter or, as in my case, celestial telescopes are used. The advantage here is the readily available pointing mechanisms. The biggest challenge with laser communications is pointing! OH2HOT has developed a dirt cheap pointing mechanism based on cheap Chinese door hinges and a couple of micrometer heads, see the drawing for more details. For cheap optical "gain", a simple Fresnel lens as used in overhead projectors will provide ample aperture.

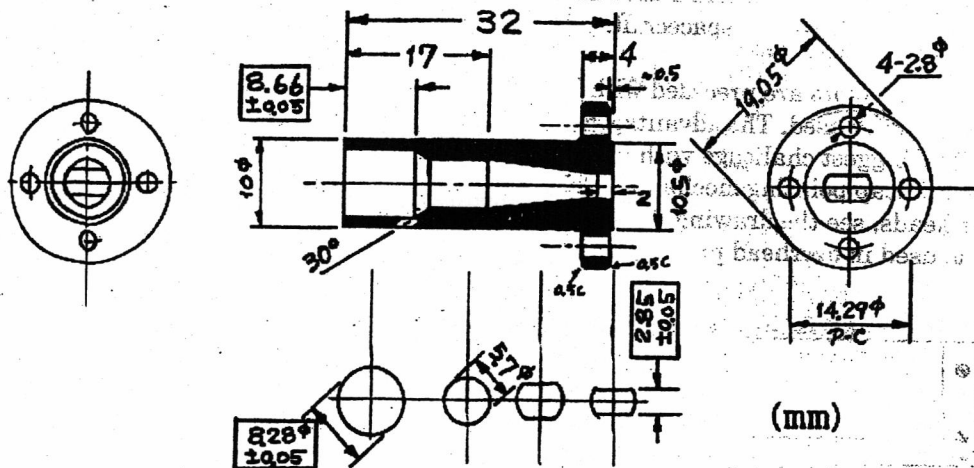


OT Laser Pointing Mechanism

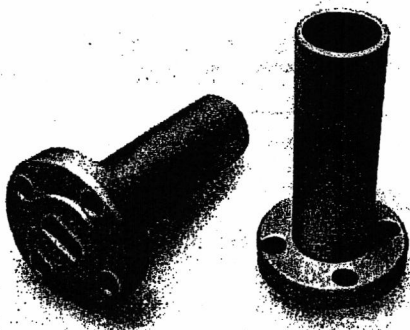
A lot of work has also been done in analyzing different plastic materials for filtering purposes. There are also very narrow bandwidth commercial filters available, some quite cheap too.

Excellent 24/47/76 GHz antenna design from Japan

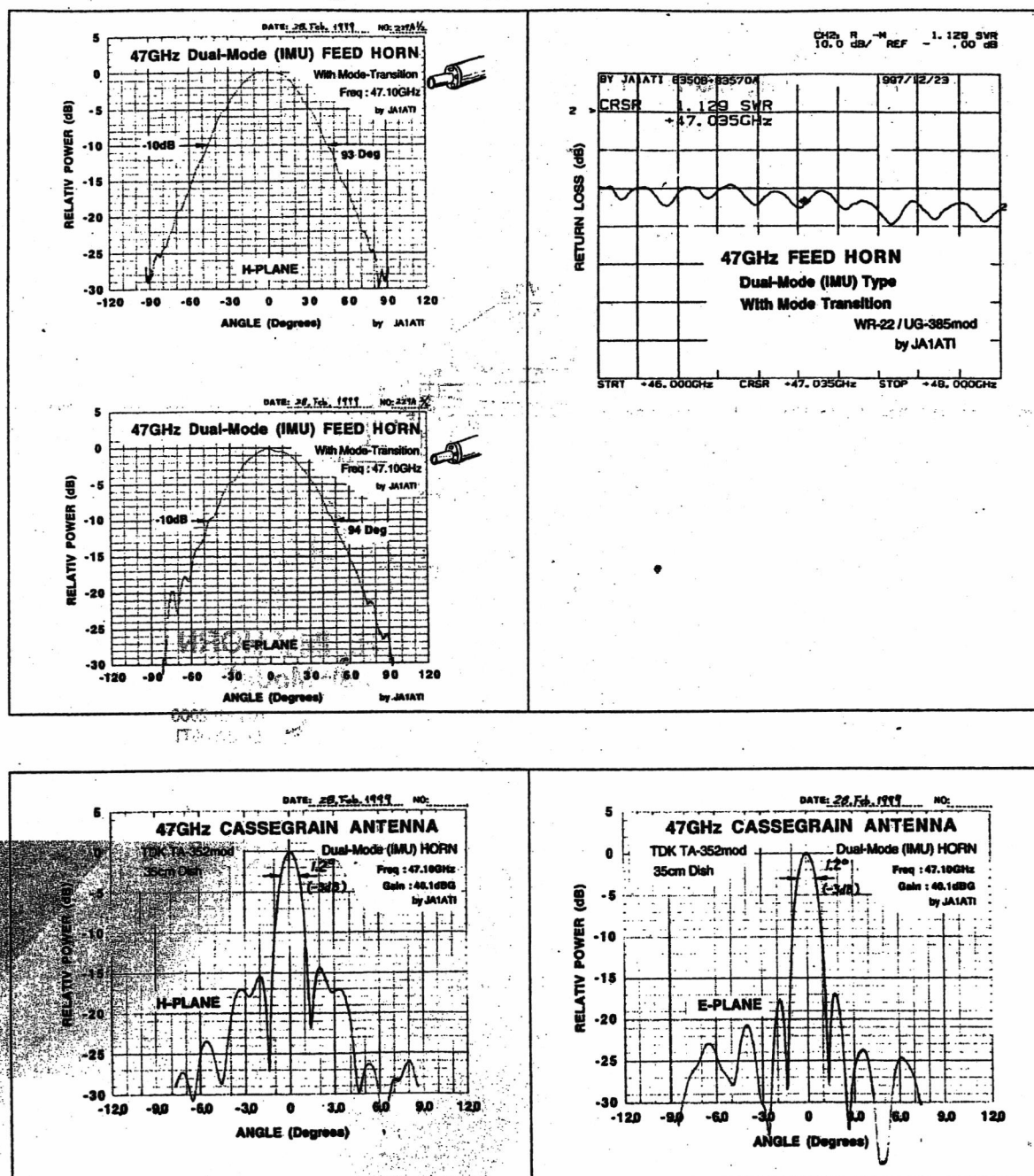
A word or two on the 76 GHz dishes: these have been designed by JA1ATI and use commercial prime focus TVRO dishes that originally were fed with a backfire helix at 12 GHz. The dishes have a very low f/D of about 0.25 and are very suitable for Cassegrain type feeding. In JA1ATI's design, the hyperbola subreflector distance can be aligned and locked easily. Also the feedhorn focal distance can be aligned easily. The mechanical construction is clearly visible in the photo. The actual feedhorn is a dual mode feedhorn for low sidelobes and is precision machined with a CNC spark erosion machine.



**47GHz Feed Horn
IMU(Dual-mode)
JA1ATI**

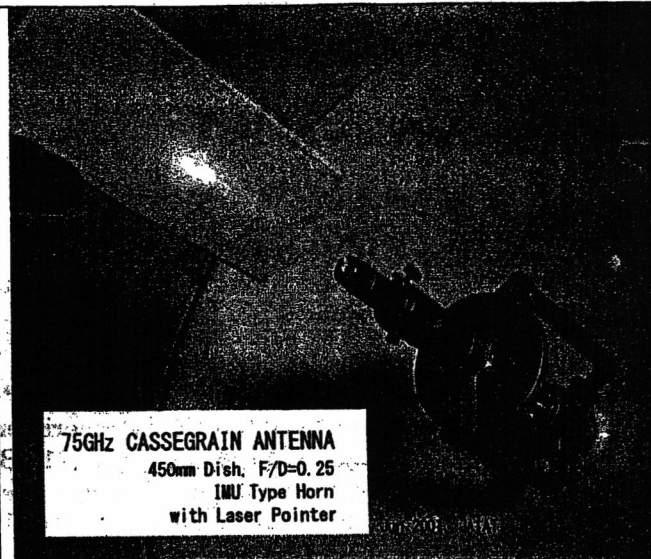
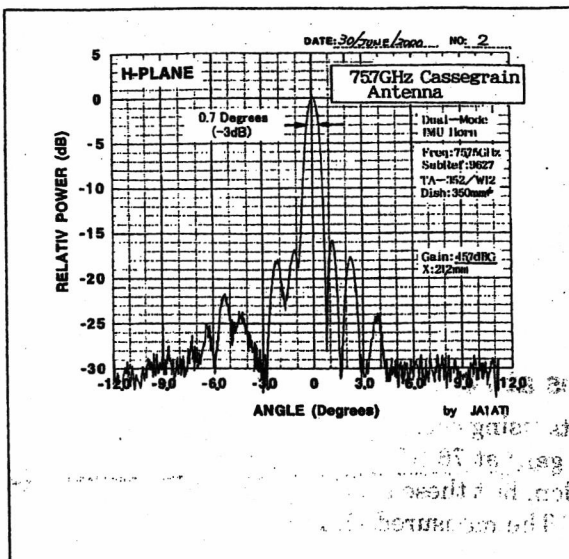
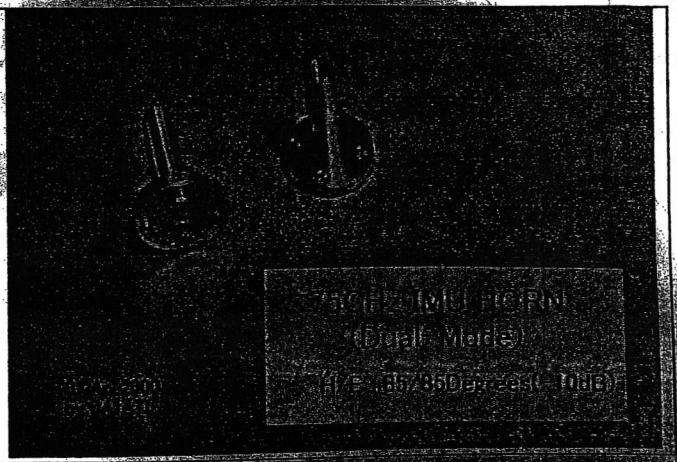
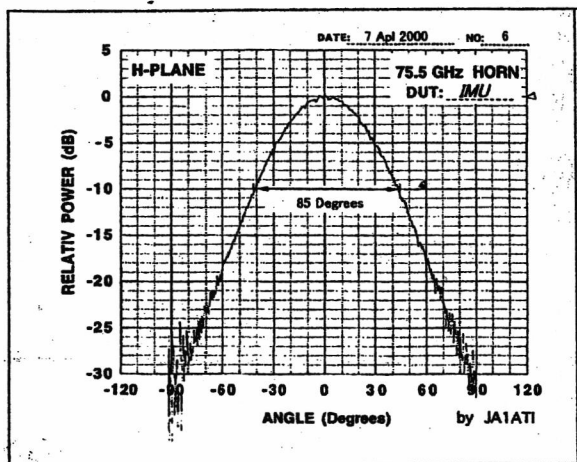
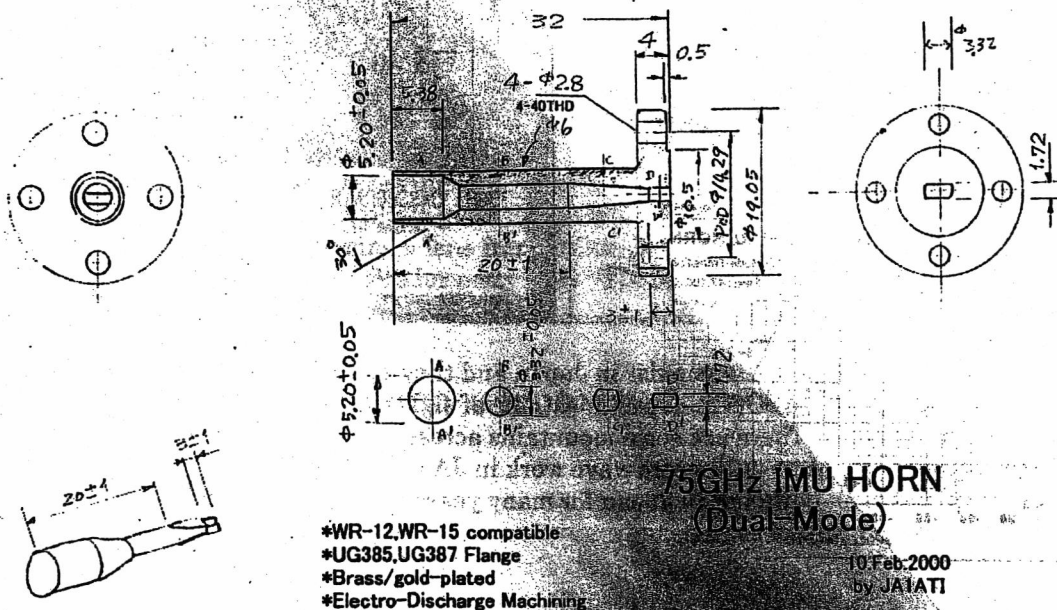


47GHz IMU(Dual-Mode)HORN
With Mode Transition
by JA1ATI



Technical characteristics of the 35 cm 76 GHz dish:

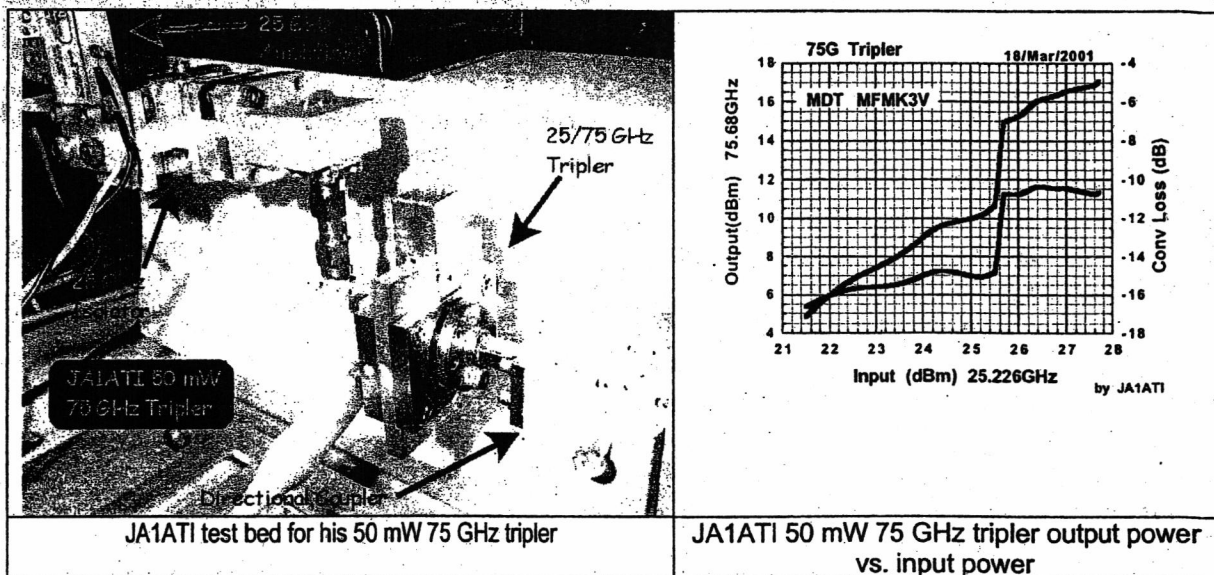
The feedhorn -3 dB measured beam width is 86 degrees as can be seen from the plot. For the 35 cm dish, the measured sidelobe level is -16 dBr with a main -3dB beam width of 0.7 degrees. The gain is measured at 45.7 dBi using a reference gain horn antenna. All measurements are made on JA1ATI's homemade antenna test range setup. This system uses a precision potentiometer for angular resolution and an Analog Devices logarithmic detector for wide dynamic range detection. 1 kHz AM modulation on the test source is used. This same reflector with a 47 GHz dualmode feed demonstrates a 1.2 degree-3 dB beam width with a 40.1 dBi gain at 47 GHz. JA1ATI has also designed a 24 GHz dualmode feed for this dish, but as I already have nice dishes for 24 and 47 GHz, I only use the 76 GHz feed at the present time. For aiding pointing, JA1ATI has also implemented a laser pointer holder structure on the hyperbola threaded section. This would also be an ideal opportunity for constructing a dual band rig 76GHz/474 THz !



These fantastic dishes are quite popular in Japan and they are being used by several hams for making long distance QSO's in Japan. Most line of sight paths end up on the slopes of Mount Fuji, near Tokyo. There are some mountains across the Tokyo Bay area that make excellent testing sites. Most millimetre wave work in JA is on NBFM audio and, surprisingly, FMATV. ATV has been quite hot in Japan for many years now, but the most serious DX'er still goes for CW and SSB of course.

Power generation at millimetrewave frequencies

Most rigs in Japan and Finland use bilateral subharmonic mixers, usually being of the LO doubling type with two antiparallel diodes giving excellent LO rejection. JA1ATI is taking things seriously though and has recently succeeded in modifying a commercial tripler to 76 GHz with a whopping output level of +17 dBm. This incredible power level combined with his smaller 35 cm dish generates an impressive 2 kW EIRP at 76 GHz !

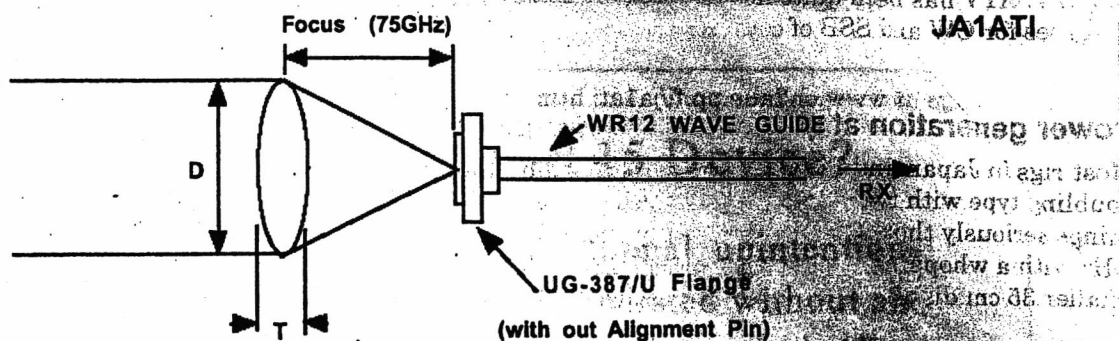


JA1ATI is building a completely new high performance transverter that uses a waveguide relay. The tripler FM output is fed via the relay to the antenna waveguide feed assembly. For reception, a balanced subharmonic mixer is used with an IF of 1280 MHz, a very popular IF in Japanese designs. The tripler needs +15 ... +18 dBm of drive at 25 GHz. This may be achieved with homebrew P-HEMT amplifiers using higher output level devices for the output and regular FHX035 or equivalent devices for the driver. JA1ATI will be using a surplus power amplifier for the driver that can supply up to +27 dBm. The amplifier is linear, so control of the drive level is easy, though surplus vane attenuators are also available and constructing your own certainly not difficult if you are not afraid of the metal work.

Interesting experiments with acrylic lenses at 76 GHz:

JA1ATI has also made some interesting experiments using cheap acrylic lenses at 76 GHz. The 25 mm diameter lens in the photo gives 21 dBr gain at 76 GHz. Improvement in efficiency could be made by turning a lens from Teflon, but these acrylic magnifying glasses can be bought from almost any store for petty cash ! The measured -3dB beam width is 9.5 degrees with a -17 dBr sidelobe level.

The 75GHz antenna which used an Optical lens



Material	Diameter(D)	Thickness(T)	Optical focus	Focus (75GHz)	Gain	Efficiency
Acrylic *1	25mm	6mm	60mm	20mm	21dB	0.25
TEFLON	75mm	28mm	—	70mm	30dB	0.35

*1: -3dB Beam width : 9.5Deg
Sidelobe, : less than -17dB

Mixer diodes for millimetre waves

One of the most common mixer diodes used is the HSCH-9521, but recently we have also found a limited source of Russian AA123B diodes that exhibit a typical noise figure of 6.3 dB with an incident LO level of 1.1 mW. In contrast to the beam lead Agilent diodes, these come in a ceramic pill package, ideal for direct waveguide assembly. Just need the machinists kind help again. These GaAs epitaxial planar Schottky devices are specified for 18 to 80 GHz operation. In our mixers, the HSCH-9521 devices have been glued down onto the substrate using silver epoxy. This is most definitely a stereo microscope operation, and even then the success rate is only about 25 - 50 %. The pill diodes are at least visible with the bare eye, but require precision machined waveguide structures to support it.

Ham millimetre/sub-millimetre wave symposium ?

Whilst the QRB's in Finland are still in the kilometre range (this is only a temporary affair !), the QSO's our Japanese colleagues are making are quite impressive and are currently well over 100 km and approaching the 200 km range rapidly.

There are also active groups on 47 and 76 GHz in Germany and UK at least. Maybe one day we could hold an international millimetre/submillimetre wave meeting somewhere in Europe to promote the cause and exchange valuable experience.

Also the submillimetre wave techniques are very interesting. Here the quasioptical nature of signal processing is increased with reflectors, filters, lenses and mixers being open structure machined devices. I have a corner cube mixer design on the drawing board, but the ham bands have yet to be allocated, not to speak of the mixer substrate and whisker material !

If any of the images in this paper are difficult to read as printed, the originals can be found on the web pages below.

Michael Fletcher, OH2AUE
www.oh2aue.pp.fi

JA1ATI subpage at www.oh2aue.pp.fi/ja1ati.htm

At WARC 79, amateurs were allocated five new millimetric bands - 47, 76, 120, 142 and 241 GHz. Although there is much still to be learnt on 24GHz and 10GHz, and indeed lower microwave bands, it would be a very worthwhile achievement simply to make a qso on these new bands. Very little information is available on designs for equipment and most of the initial work will be experimental. Here is a summary of some data and a few ideas for 47GHz and 76GHz in the hope that it will encourage a few readers into action building gear. Particular thanks are due to G3HWR for the absorption data.

1. VARC Allocations

47.0 to 47.2GHz exclusive

75.5 to 76.0GHz exclusive, 76.0 to 81.0GHz secondary

No news of availability in the UK yet.

2. Frequency of Operation

For crystal controlled equipment, a frequency of 76032MHz suggests itself, being 1152 times 66. No useful relation has been found for the 47GHz band (the nearest multiple of 1152 is just outside the band at 47232MHz) and the only suggestion is to use a multiple of 96MHz ie 47040 or 47136MHz.

A free running oscillator (ie a Gunn) on 47GHz would easily tune the whole band. On 76GHz, this probably would not be the case and so it might seem sensible to aim to operate fairly close to 76032MHz.

9.2 Propagation

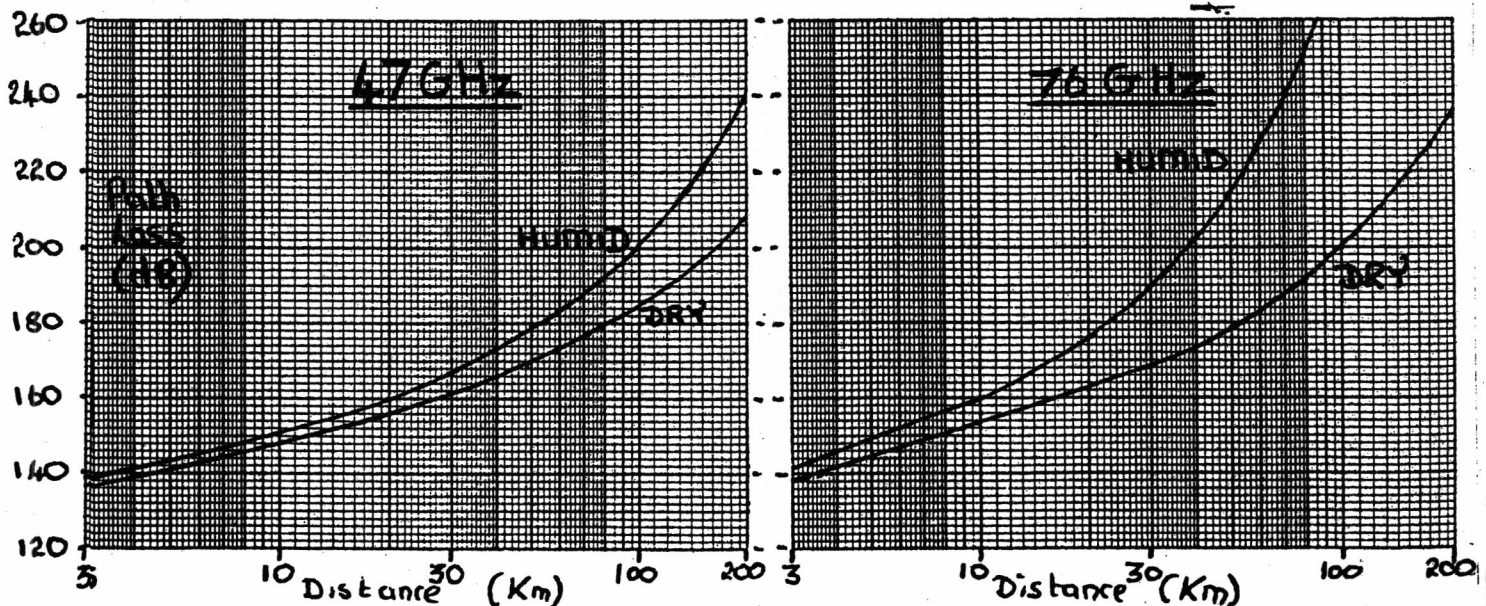
9.2.1 Atmospheric Attenuation

On the centimetric bands, any optical path in the UK can be worked with even simple equipment. This would also be true on 47GHz and 76GHz if it were not for absorption in the atmosphere. In dry air, absorption is mainly due to oxygen, but significant additional attenuation is caused by water vapour. What matters here is the absolute mass of water vapour present in the atmosphere so that attenuation may be more severe on a humid summer day than a wet but cold winter day. If the temperature is below freezing the water content of the atmosphere is very low - this might be the best time to operate! Some approximate figures for the attenuation and the comparative ones for 10GHz and 24GHz are shown below. These do not include rain across the path, which will cause the attenuation to increase very considerably at 47GHz and above.

Band (GHz)	Attenuation (dB/km)		
	Dry Air	Moderate Humidity	High Humidity
10	0.015	0.02	0.03
24	0.022	0.16	0.30
47	0.18	0.20	0.35
76	0.3	0.4	1.0

9.2.2 Path Losses

These figures can be combined with the free space loss to obtain approximate path loss figures as a function of distance. These are plotted on the two graphs below for 47GHz and 76GHz. The loss figures represent the loss between two isotropic antennas over the corresponding distance. Note that the humid air figures are for high humidity.



9.3 Ideas for Getting Started

The simplest suggestion is to use a mixer diode as both a mixer (on receive) and a multiplier (on transmit and receive) where the diode acts as a doubler or tripler. Thus on 47GHz a signal at 23.5GHz from either a Gunn or varactor diode could be doubled. This might be implemented using some sort of coupler arrangement, made from two different waveguide sizes (eg WG20 & WG24) with the mixer diode sitting in the junction. The IF could be taken from the diode to a conventional IF strip.

G3WDG points out that the output from a Gunn diode usually contains a considerable amount of the 2nd harmonic - it may only be 10 or 15dB down on the fundamental. Thus a GD033 module could be retuned to 23.5GHz and a simple filter placed on the output in WG24 to reject the fundamental. Thus a low power tx or local oscillator is easily built.

For an antenna gain of 37dB, which corresponds to a 3' dish on 10GHz, the dish sizes on 47GHz and 76GHz are 12 and 7 inches approximately. However, horns are quite practical antennas at these frequencies and are especially attractive as no critical feed matching is needed. The aperture sizes for a gain of 30dBi are 9cm by 7.5cm on 47GHz and 5.5cm by 4.5cm on 76GHz - similar in size to a 15dBi horn on 10GHz. These sizes will give a beamwidth of about 5 degrees, corresponding to a dish size of 18 inches on 10GHz.

The standard waveguides are listed in the VHF/UHF manual, but an alternative are the brass rectangular sections mentioned by G3HWR

G3HWR has had some interesting ideas about waveguide for the new millimetre bands :-

"Waveguide sizes are agreed internationally for frequencies up to at least 300GHz and for amateurs with access to them, these are the best to use.

For home built equipment which does not require to connect to other equipment, it is not necessary to use standard waveguide and non standard waveguide quite adequate in short lengths can be bent up from sheet metal.

Useful extruded metal sections are available from the model trade, these are used by modellers to represent the corresponding steel sections ie., angle, I-beam, T-beam and square and rectangular box sections!

These extruded sections used by the model trade are available from R. M. Trading Co., 646 High Road, N Finchley, London N12 0NL, Telephone 01-445-6531.

Attached is a list of the important properties of the four rectangular sections and the waveguide obtained when a channel section is attached to a flat sheet."

For getting going on the millimetric bands, G3JHM suggests the use of sub-harmonic mixing: $F_{sig} - 2 \times F_{lo} = F_{if}$. This will enable existing multipliers to 24GHz to be used for a 48GHz downconverter, for example. The sub harmonic mixing enables a simpler design of mixer circuit to be used since the frequency separation between F_{sig} and F_{lo} is much greater. This technique has been studied by several workers at BTL and TRG (Alpha) and may be applied from 1GHz to at least 183GHz. Don says he has a bibliography and copies of the relevant papers if anyone is interested. In general, the realisation of the circuits is by using stripline mounted symmetrically in waveguide, with the base material being quartz substrate but it may be possible to use polyguide or other microwave pcb materials.

Cat No K & S	Description		Qty/Ht g Hz	Useful Band (GHz)	Amateur Band			
	Type	O.D. in. mm	I.D. in. mm		GHz	λair(m)	λg	λg/λa
262	□	.187 X .093 4.76 X 2.38	.156 X .063 3.96 X 1.60	37.8	40 to 75	47 47.2		
264 47	□	.250 X .125 6.35 X 3.18	.209 X .094 5.35 X 2.38	26.98	30 to 52	47 47.2	.6378 .635	.7785 .7734
266	□	.313 X .156 7.93 X 3.97	.281 X .125 7.14 X 3.18	21.0	24 to 41	24.0 24.192 24.25	1.249 1.239 1.236	25.72 24.96 24.65
268	□	.375 X .188 9.53 X 4.76	.344 X .156 8.74 X 4.0	17.17	20 to 34	24.0 24.192 24.25	1.249 1.239 1.236	18.18 17.86 17.78
181	□	.125 X 3.175 X	.0937 X 2.38 X	62.94	70 to 125	76.0 76.03 81 120	3.94 3.70 2.50	7.029 5.878 2.936
184	□	.219 X 5.56	.188 X 4.76	31.47	35 to 60	47 47.2	6.38 6.35	8.558 8.522



METALS AND TOOLS

Send to: R.M. Trading Co., 646 High Road, N. Finchley, London N12 0NL, Tel: 01-445 6531
EXCLUSIVE U.K. IMPORTERS OF K & S PRECISION ENGINEERING PRODUCTS

Metal Centre

Complete kit, inc. display stand contains a selection of the following items.

ALUMINIUM TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
100	15	1/8"	.25	
101	12	3/32"	.30	
102	12	1/4"	.35	
103	12	5/32"	.35	
104	12	3/16"	.40	
105	10	7/32"	.45	
106	10	1/2"	.50	
107	8	5/8"	.55	

COPPER TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
117	20	1/16"	.25	
118	15	3/32"	.30	
119	12	1/4"	.35	
120	12	5/8"	.40	

SOFT BRASS FUEL TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
121	10	1/8"	.40	

BRASS STREAMLINE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
122	4	Small	.75	

ROUND BRASS TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
125	20	1/16"	.30	
126	15	3/32"	.35	
127	15	1/4"	.40	
128	12	5/32"	.35	
129	12	3/16"	.45	
130	10	7/32"	.50	
131	8	1/2"	.55	
132	8	5/8"	.60	
133	6	3/4"	.65	
134	6	7/8"	.70	
135	6	1"	.75	
136	4	1 1/8"	.85	
137	4	1 1/4"	.90	
138	4	1 1/2"	.95	
139	4	1 3/4"	1.00	
140	3	1 7/8"	1.05	
141	3	2"	1.10	
142	2	2 1/8"	1.25	
143	2	2 1/4"	1.35	
144	2	2 1/2"	1.40	

SQUARE BRASS TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
149	12	1/16"	.45	
150	12	3/32"	.50	
151	12	1/4"	.55	
152	10	5/32"	.65	
153	8	3/16"	.75	
154	6	7/32"	.85	
155	6	1/2"	.95	

SOLID BRASS ROD (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
159	50	.020"	.05	
160	50	1/32"	.08	
161	34	3/64"	.12	
162	20	1/16"	.20	
163	16	3/32"	.25	
164	10	1/8"	.40	
165	8	5/32"	.50	

BRASS ANGLE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
171	10	1/8"	.40	
172	10	3/16"	.45	
173	8	1/4"	.50	
174	7	5/16"	.55	
175	6	3/8"	.65	

BRASS CHANNEL (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
181	10	1/8"	.30	
182	8	3/16"	.35	
183	6	1/4"	.40	
184	5	5/16"	.45	
185	4	3/8"	.50	

ROUND PLATED SPRING WIRE (12 inch)

Ref No.	Quantity	Size	Price Per Item	Total
187	50	.032"	.05	
188	50	.040"	.05	
189	50	.050"	.05	

BRASS STRIPS (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
230	20	.016"	.20	
231	15	.018"	.30	
232	10	.016"	.50	
233	10	.014"	.40	
234	5	.016"	.40	
235	15	.025"	.25	
236	10	.025"	.40	
237	6	.025"	.70	
238	6	.025"	.55	
239	3	.025"	1.30	
240	15	.037"	.20	
241	10	.037"	.50	
242	5	.037"	.85	
243	6	.037"	.65	
244	3	.037"	1.60	
245	8	.064"	.60	
246	4	.064"	1.00	
247	3	.064"	1.75	
248	2	.064"	1.70	
249	3	.064"	3.70	

SHEET METAL (4 x 10 Sheets)

Ref No.	Quantity	Size	Price Per Item	Total
250	6	.005"	.20	
251	6	.010"	1.10	
252	6	.015"	1.50	
253	3	.027"	2.70	
254	6	.008"	.50	
255	6	.016"	.50	
256	6	.032"	.80	
257	6	.064"	1.35	
258	6	.075"	1.30	
259	3	.075"	2.60	

RECTANGULAR BRASS TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
263	4	3/32"	1.10	
264	4	1/8"	1.20	
265	4	5/32"	1.30	
266	4	3/16"	1.60	

HEXAGON BRASS TUBE (12 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
221	8	3/32"	.55	
222	7	1/8"	.65	
223	6	5/32"	.75	
224	5	3/16"	.85	

Wire & Tube Centre

Complete kit, inc. display stand contains a selection of the following items.

FLANG WIRE (36 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
498	50	.015"	.10	
499	47	.020"	.12	
500	34	.025"	.15	
501	34	.037"	.15	
502	34	.047"	.15	
503	37	.055"	.18	
504	30	.063"	.17	
505	25	.078"	.20	
506	17	.100"	.20	
507	12	.125"	.25	
508	8	.150"	.25	
509	5	.175"	1.00	
510	4	.200"	1.25	
511	3	.250"	1.70	

STREAMLINE TUBE (36 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
1100	5	1/8"	1.50	
1101	5	5/16"	1.80	
1102	4	3/8"	2.10	
1103	4	1/2"	2.40	
1104	3	5/8"	2.70	
1105	2	3/4"	3.00	

ROUND ALUMINIUM TUBE (36 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
1106	8	3/32"	.90	
1107	8	1/8"	.90	
1108	6	5/32"	1.05	
1109	6	3/16"	1.20	
1110	6	7/32"	1.35	
1111	5	1/4"	1.50	
1112	5	5/16"	1.65	
1113	5	3/8"	1.80	
1114	5	7/16"	1.95	
1115	5	1"	2.10	

ROUND BRASS TUBE (36 inch Length)

Ref No.	Quantity	Size	Price Per Item	Total
1143	10	1/16"	.30	
1144	8	3/32"	.35	
1145	8	1/8"	.40	
1146	6	5/32"	.45	
1147	6	3/16"	.50	
1148	6	7/32"	.55	
1149	5	1/4"	.60	

Tools and Accessories

Ref No.	Quantity	Item	Price Per Item	Total
298	3	Tubing Cutter	3.95	
321	6	Tubing Bore	1.50	
707	6	Brass Connect	1.00	

DISPLAY RACKS

Ref No.	Quantity	Item	Price Per Item	Total
1008		Steel Rack	309.00	
2400		Wire Rack	189.00	
5607		Easy Rider	84.00	

Total	Sub Total	Grand Total

†Not included in Wire and Tube Centre.
*Included in Easy Rider add on set for 1000 Metal Centre.
In the interest of accuracy and speed of service, orders must be placed in quantities only. Please direct your orders to any quantity required.