A 10GHz Gunn Diode controller.

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As many people have found out, its very simple to produce a TV picture from a Gunn diode oscillator but very difficult to achieve high quality pictures and sound. This design overcomes many of the problems experienced with simpler circuits yet is still easy to construct and set up. All the components, with exception of the etched PCBs are available from Maplin Electronics. The boards can be home made, the track and component layouts are included in this article.

Changing the voltage across a Gunn diode causes the frequency and amplitude of its oscillations to shift. Since most receivers can effectively ignore amplitude variations at video rate, only the frequency modulation effect will be used. To see how the design was developed we must first analyse the deficiencies and merits of each method of driving Gunn effect devices and then utilise the most suitable method in a way that allows home construction.

The goal is to present the video information, sound subcarrier and adjustable DC supply voltage to the Gunn device simultaneously. This isn't too difficult to achieve if the mixing of these signals can be done very close to the Gunn diode and sufficient video and sound drive can be produced to feed the low impedance at this point. In the real world, the Gunn diode may be located up a mast or high on a wall where accessibility is poor and long cable runs would be needed. Apart from the requirement for separate audio, video and DC feed cables, the load impedance for each is quite different and matching components would be necessary with the. inherent losses they would introduce.

Three options are open:

1 . to run three cables to a modulator unit co-located with the Gunn oscillator
2.. to mix the signals together at source and feed them to the oscillator via a single cable,
3. to mix audio, video and a tuning signal together, fed them through a single cable and add the DC supply at the oscillator end.

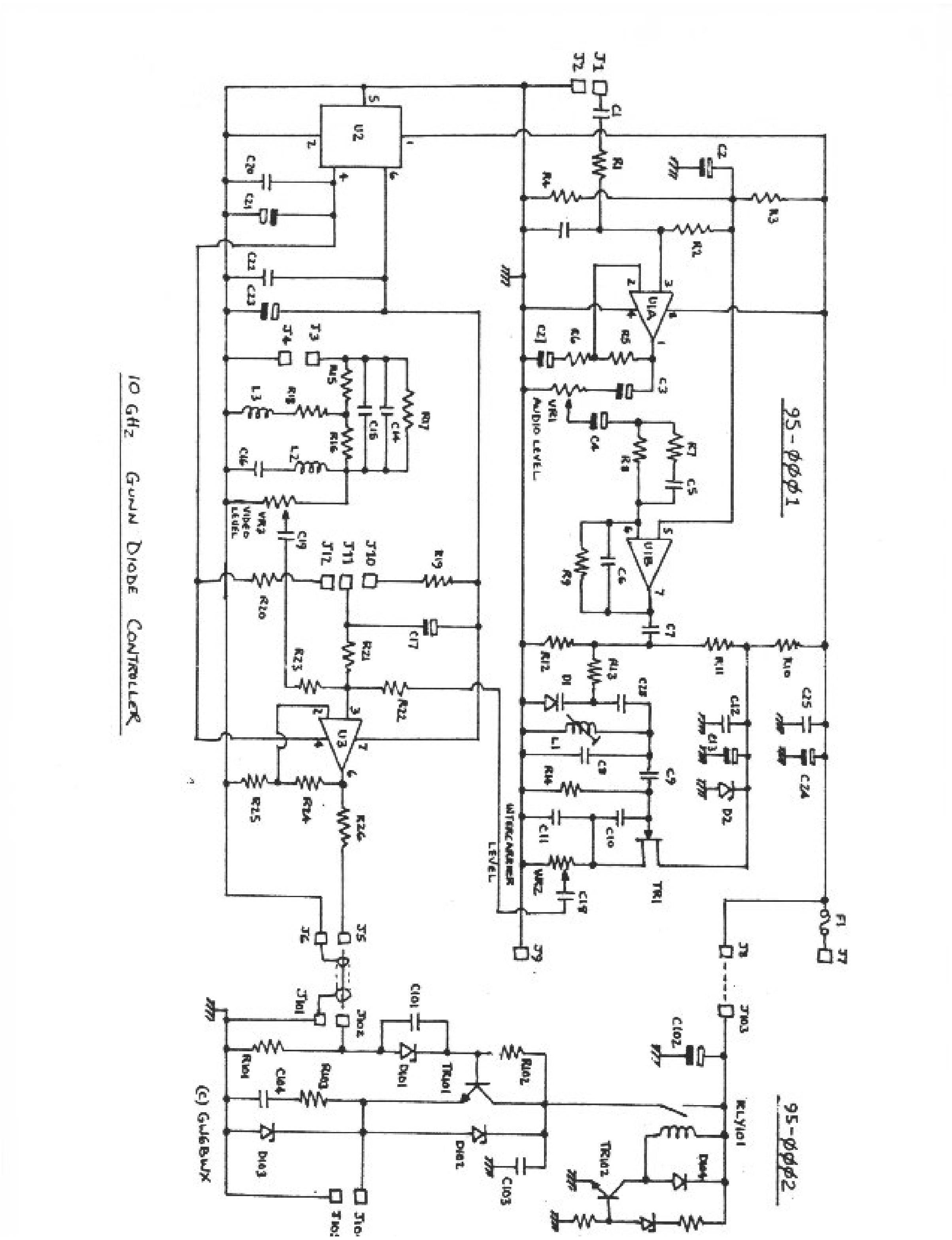
Option 1 is most expensive in terms of cabling, also losses in the impedance matching networks require that considerable signal power is generated. Option 2 is least expensive to implement but the complex and varying impedance of the Gunn diode makes matching to coax very difficult. The mismatch would show as video ringing, ghosting and probably missing frequencies due to phase cancellation in the standing waves along the cable. The missing frequencies could well include the sound or colour subcarriers. Option 3 is technically most complicated but requires only one coax cable to carry the signals and a separate unscreened cable to carry the DC supply. The third option is the one chosen in this design.

Circuit description:

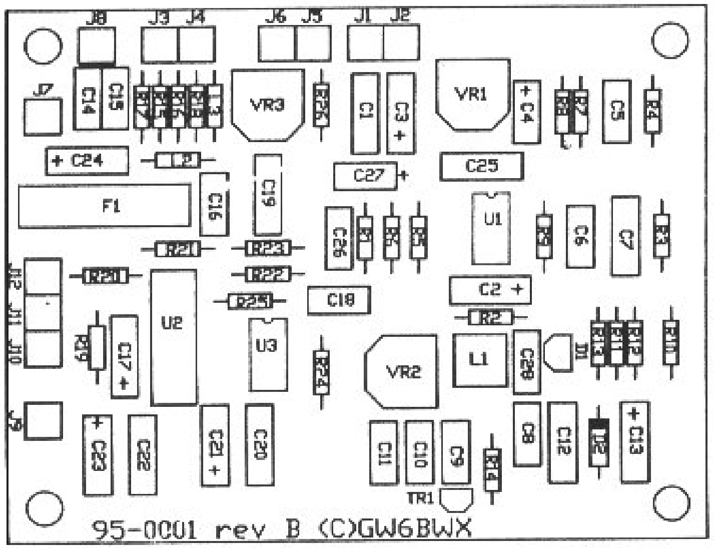
Overall, the design occupies two small PCBs, one mounted at the "shack end" of the cable which deals with the signal processing, the other is located close to the Gunn head and provides the adjustable DC supply. The coax cable is driven and loaded with 75 ohm impedance to correctly match the cable and prevent signal distortion, even when long lengths are used. Changing the values of R26 and R101 to 51 ohms will allow 50 ohm impedance coax to be used instead but the supply current will be slightly increased. Looking at the main PCB (95-0001) first; the circuitry around U 1 is a two stage audio amplifier giving sufficient gain to allow direct connection to a microphone. It also provides high frequency pre-emphasis necessary to give an overall flat response when received through a satellite receivers de-emphasis circuits. The audio signal is then DC blocked by C6 and fed to a varicap diode which has a steady 4 volt reverse bias to centralise its capacitance swing. As the varicap changes capacitance it frequency modulates the subcarrier oscillator formed from components around TRl . The oscillator and varicap supplies are stabilised by D2 to prevent frequency drift if the power source fluctuates. Video arriving at J3 is fed through a pre-emphasis network and 6MHz trap. The trap slightly upsets the video phase response but with the values suggested its phase shift passes through 0 degrees at almost exactly 4.4 MHz so colour distortion is minimal. If desired the trap can be omitted by not fitting L2 and C16. The video and sound are mixed with the tuning voltage at pin 3 of U3 which is configured with a gain of 2 to offset the halving of the signal in the coax feed and load resistors R26 and R101 . In order to reduce current flow through the co-ax and hence its load resistor, the tuning is achieved by sitting the combined sound and vision signals on a DC offset of between +1 and -1 volts. If adjusted correctly the offset should be Ov and no load current will flow. To generate the negative voltage a modular DC-DC inverter is used (U2). This gives +12 and -12 volt outputs which track each other fairly closely. By using the +l2 output from U2 instead of the main power rail, any variation is supply is balanced and has no effect on tuning voltage. Pin 3 of U3 is a high impedance point and therefore offers little loading to the sound or vision signals and permits isolating resistors R22 and R23 to be used. C17 filters noise from the tuning potentiometer wiring and is returned to the +12 rail so its switch-on charge momentarily raises the Gunn voltage, this has been found necessary on some diodes to "kick start" them into oscillation.

On the second PCB (95-0002), the co-ax cable is matched into load resistor R10l. If the tuning is correctly set there will be no DC voltage across this resistor. D101 and R102 lift the signal from the cable so it sits 8.2 volts above its previous level. TR101 is used as a current amplifier to drive the Gunn diode itself. As its emitter voltage will sit about 0.7 volts below that at its base pin, the Gunn should have 7.5 volts across it, nicely central in its operating range. By adjusting the tuning control the voltage across R101 should swing approximately +1 to -1 volts so the Gunn voltage will swing approximately 6.5 to 8.5 volts which are about its safe limits. D102 and D103 prevent the Gunn voltage dropping more than 6.8v below supply or 9.1v above ground should the tuning voltage exceed safe limits. R103 and C104 form a 470 ohm shunt which helps the Gunn diode appear less reactive and reduce its tendency to oscillate in undesirable modes. If the wires to the Gunn module are longer than about 10cm (4") fit them at the diode instead of on the PCB. As a protective measure, relay RLY1 will only close and connect the Gunn voltage if the supply voltage exceeds about 9.5 volts. A voltage low enough to bias the diode below its negative resistance region can cause excessive current to flow.

Circuit Diagram:

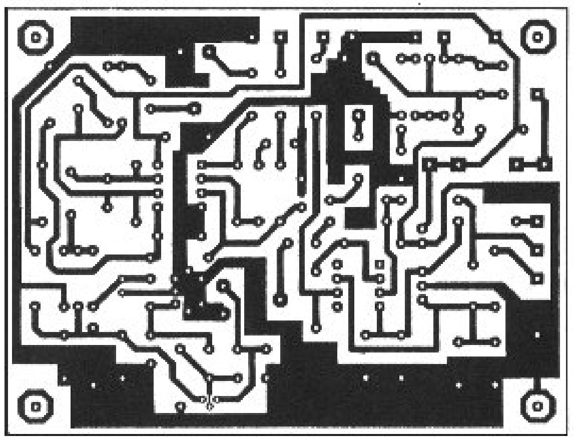


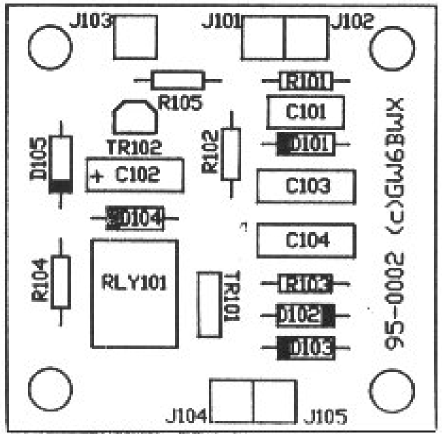
PCB Layouts:



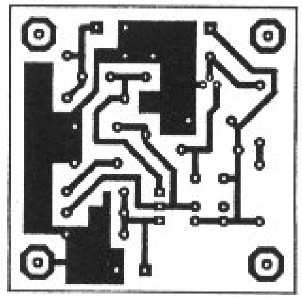
PCB Connections

J1	Audio input - signal
J2	Audio input - ground
J3	Video input - signal
J4	Video input - ground
J5	Co-ax to 95-0002 - inner
J6	Co-ax to 95-0002 - braid
J7	+12 volts supply input
J8	+12 volts to 95-0002
J9	0 volts supply ground
J10	"HF" end of tuning control potentiometer
J11	wiper of tuning control potentiometer
J12	"LF" end of tuning control potentiometer
J101	Co-ax from 95-0001 - braid (from J6)
J102	Co-ax from 95-0001 - inner (from J5)
J103	+12 volts from 95-0001 (from J8)
J104	"Live" to Gunn diode assembly
J105	Ground to Gunn diode assembly chassis





TRACK LAYOUTS ARE ACTUAL SIZE



Parts List: (Codes are for Maplin Electronics orders)

Value	*Code*	*Qty*	*Reference*
l8	Ml8R	1	R18
75	M75R	3	R 15, R 16, R26 (R26 may be M51R, see text)
82	M82R	1	R l 01 (R101 may be M51R, see text)
300	M300R	1	R17
390	M390R	1	Rl0
470	M470R	1	R103
560	M560R	l	R104
1K	M1K	5	R1 R23, R24, R25, R102
2K2	M2K2	3	R6, R7, R22
10K	M10K	5	R3, R4, R5, R13, R21
47K	M47K	1	R2
56K	M56K	2	R19, R20
68K	M68K	1	R8
100K	M100K	3	R1l, R12, R105
330K	M330K	2	R9, R14
l K	UH00A	3	VR1, VR2, VR3
22p	WX48C	3	C6,C8,C18
33p	WX50E	2	C10,C11
68p	WX54J	1	Cl6 (if required, see text)
100p	VX56L	1	C28
680p	WX66W	2	C l 5, C26
1n	WX68Y	4	C5,C9,C14,C101
0.lu	WW4lU	9	Cl,C7,C12,C19,C20, C22, C25, C103, C104
2u2	YY32K	2	C4, C27
l0u	YY34M	3	C2, C3, C17
47u	YY37S	5	C13, C21, C23, C24, C102
10uH	WH35Q	2	L2, L3 (L2 if required, see text)
15uH	UH86T	1	L1
6V8	QF49D	l	D102
8V2	QF51F	2	D2, D101
9V1	QF52G	2	D103, D105
1N4148	QL80B	1	D104
MV1208	QY81C	1	D1
BF244	QFl6S	1	TR1
BD131	QF03D	1	TR101
BC337	QB68Y	1	TR102
TL072	RA68Y	1	U1
NMA1212	AH17T	1	U2
EL2020	UR06G	1	U3
RELAY	DC52G	1	RLY1
VEROPIN	FL24B	1	J1 - J12, J10l – J105 (1 x FL24B = 100 pins)

Tuning control either 10 turn or single turn but MUST be 10K value and preferably linear track. This part is not mounted on the PCBs. Use a type that suits your preferred box or enclosure.

Assembly:

All PCB holes are 0.8mm except the fuse clips which are l.5mm, TR101 and the L1 can legs which need 1 mm holes. All resistors, diodes and fixed inductors are mounted on 0.4" spaced holes, 0.1uF capacitors and electrolytics are on 0.3" spacing and ceramic capacitors are on 0.2" spacing. Pre-forming the leads before assembly will greatly speed construction. Assembly order isn't critical but I suggest fitting the two fuse clips first as these need their pins folding together on the track side, a job more easily done before fragile components are fitted. Fit U2 and L1 last as these are the tallest parts and are easily damaged during handling. The only awkward soldering is around TRI, be Careful not to short its pins together.

Alignment:

There will be a small amount of interaction between the adjustments, it was felt that the addition of buffer stages would make the design considerably more complicated and expensive while offering little advantage. In particular, the sound frequency (L1) and intercarrier level [VR2} will affect each other, it may be necessary to repeat adjustments two or three times to achieve optimum results. The sound and video levels are set by VR1 and VR3 ; respectively, they have no interaction and should be set to give best modulation levels.

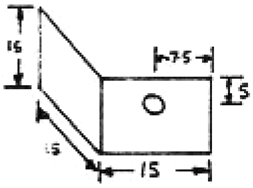
Initially, the transmitter frequency should be set. As the tuning control will only allow adjustment over about 60MHz (varies widely according to the Gunn module). it should be set to give most shift above and below the desired centre frequency. Connect a voltmeter between J5 and J6 and adjust the tuning control for zero voltage, then adjust the tuning screw on the Gunn module until the frequency is correct. If using the repeater you can adjust the screw until the best picture is rebroadcast. The voltage at J5 should swing approximately 1V positive and negative as the tuning control is turned from end to end. the exact voltages are not critical but must not exceed 1.5V.

To adjust the sound subcarrier oscillator, set VR2 to mid position and adjust L1 to achieve most quietening of the background hiss while monitoring on a receiver or the repeater. If a frequency counter is available, disconnect the cable from J5 and attach the counter in its place, set VR3 to minimum and adjust L1 for 6.OOMHz. The intercarrier level is a little more difficult to set, the object is to provide sufficient carrier to fully quieten the sound channel but no more. Excessive level will do nothing to improve sound performance but may cause patterning on colours. Find the level that kills receiver noise and set VR2 just beyond that point. Repeat the adjustment of L1to make sure it hasn’t pulled too far off frequency.

Hardware notes:

Both PCBs have one mounting hole attached to ground through a narrow track. This hole can be used to ground the board to a screened box if a suitable conductive pillar and washer are used. If for any reason you do not wish to ground the board this way, simply cut the track with a sharp knife to isolate the mounting.

TR101 runs fairly warm without any heatsink. If desired, a small angled aluminium heatsink. can be fabricated to the design below. There is space on the PCB to mount it.



HOLE IS 3MM DIAMETER
MOUNT TR101 TO THE HEATSINK BEFORE
SOLDERING IT IN PLACE.

DATES FOR YOUR DIARY

S.T.G (A.G.M)	11 th April 9S, 7:30pm, Elm Park Pavilion, Filton, Bristol
BATC RALLY	30th April 95, The Sports Connexion, Coventry
LONGLEAT RALLY	25th June 95, Longleat Safari park, Warminster.
BRISTOL RALLY	3rd Sept 95, Temple Meads, Bristol.